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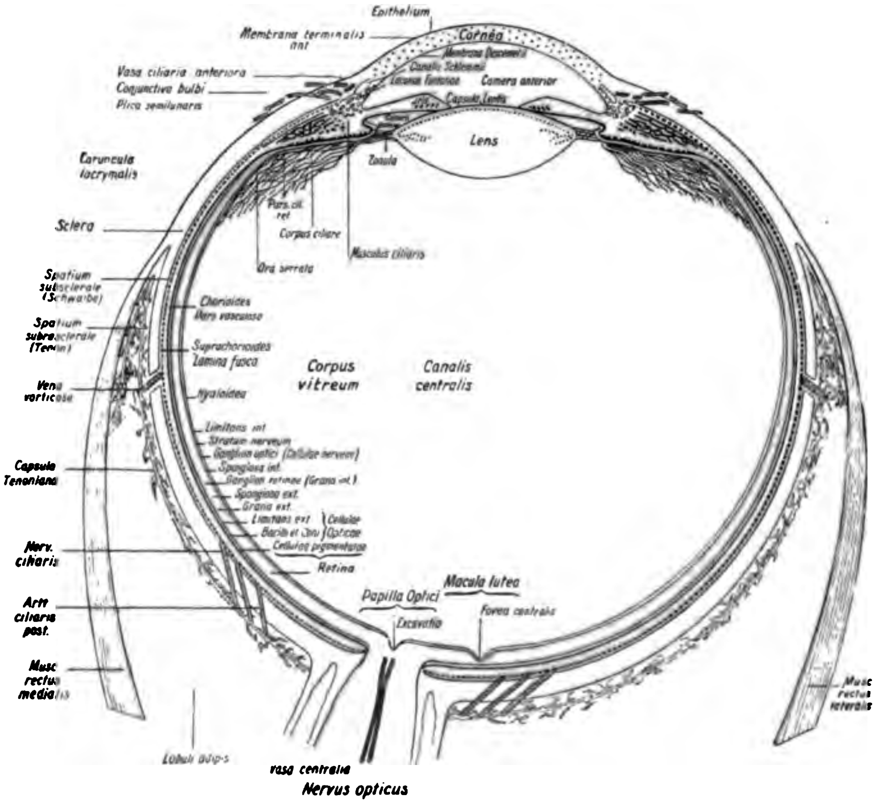

PLATE I.—LONGITUDINAL SECTION OF THE EYEBALL. (MAGNUS.)

DISEASES OF THE EYE

BY

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*WITH FIVE COLOURED PLATES AND TWO HUNDRED AND
NINETY-SIX ILLUSTRATIONS IN THE TEXT*

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THIS WORK
IS AFFECTIONATELY DEDICATED TO
THE MEMORY OF

LUDWIG MAUTHNER, M.D.
PROFESSOR AT THE UNIVERSITY OF VIENNA.

MY EARLIEST TEACHER OF OPHTHALMOLOGY;
A MAN OF RARE ABILITY AND
THE GREATEST OPERATOR
OF HIS DAY.

66426

PREFACE

THE following treatise is the outgrowth of a series of lectures delivered by the author at the Medico-Chirurgical College and Hospital during the last ten years. Its object is not to supply a mere ephemeral sketch of existing information on ophthalmology, but to provide a digested summary of the known facts for use of students who in after-life become practitioners of medicine. This work is based on an extended experience. The author has aimed at simplicity of diction in an effort to present to them, in language they can comprehend, the principles which underlie the normal as well as the pathological changes that take place in the eye and its appendages.

Common knowledge as regards the subject of ophthalmology has been freely used, supplemented, however, by the author's own views of pathology and methods of treatment, together with the results of the most recent investigations and experiments. The arrangement of the work differs materially from most text-books on the subject. The diseases are considered according to the structures attacked in the order in which they are encountered in going from without inward. Refraction and ametropia are consequently considered in the latter part of the book on account of the influence they exert on all ocular conditions. Among the articles of special importance, the reader's attention is directed particularly to those upon albuminuric retinitis, hæmorrhagic retinitis, lid operations, declinations of the retinal meridians, cataract, glaucoma, and diseases of the orbit. In the line of therapy, X-ray work is undoubtedly the most beneficial of the recent discoveries. The subconjunctival injection of salt solutions in iritis and corneal ulcers, peridectomy in pannus, grattage in trachoma, and the use of opaque slips combined with correcting lenses for conical cornea, are likewise given the prominence to which they are entitled in the subject of treatment.

In an endeavour to render each chapter a complete essay on the subject mentioned in its heading there has resulted a certain amount of repetition of the elementary points. Much has necessarily been left unsaid. For students who wish to follow the practice of ophthalmology exclusively, the author has simply laid a foundation upon which, by practise and careful observation, they may build for themselves a broad reputation and confer upon the afflicted the greatest of all benefits, the restoration of vision.

The author is indebted to Dr. H. D. Jordan for complete stenographic reports of his didactic lectures, and to Dr. David F. Hummel (gold medalist) for reports of his surgical clinics. The author also wishes to acknowledge his indebtedness to Dr. Samuel Horton Brown for the valuable aid rendered in compiling, indexing, etc., this work.

To D. Appleton and Company, and to other publishers, the author is likewise under obligations for the use of certain illustrations. The various courtesies extended by the publishers during the preparation of this work cannot be passed without mention.

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DISEASES OF THE EYE

CHAPTER I

DEVELOPMENT OF THE EYE

FOR the sake of simplicity, the eye, one of the organs of special sense, may be divided into three parts:

(1) The receiving portion—the eye proper—consisting of a sensory layer (the retina) situated at the focusing point of a compound system of lenses, the power of which is regulated by the action of the muscles of accommodation.

(2) The transmitting portion, which is composed of nerve material.

(3) The percipient portion, that area of the cerebral cortex which is made up of the distributed central portions of the nerve material.

The *optic vesicle,* which is the first indication in the development of the visual apparatus, makes its appearance in the human embryo about the fifteenth day as a large diverticulum extending on each side of the primary cerebral vesicle, and subsequently becoming connected with the interbrain or thalamencephalon. The optic vesicle continues to develop, until at about the twentieth day it lies directly under, and in contact with, the ectoderm. As the development progresses, the ectoderm opposite the external pole of the vesicle thickens; this area of ectodermic thickening is the first indication of the crystalline lens, the development of which proceeds as follows:

The thickened ectoderm at this point becomes depressed, forming an everted pouch which is directed towards the optic vesicle, the anterior wall of which it invaginates. This invagination progresses until a closed sac, the *lens vesicle,* is formed, which, eventually separates from the ectoderm. The lens is accordingly an epithelial structure, being derived from the external germinal layer or ectoderm. In the first stages of its development it consists of a hollow vesicle, which later becomes filled by the growth of its cells and is converted into a solid spherical mass.

Simultaneously with the formation of the lens the anterior segment of the optic vesicle is forced in by the growing ectoderm, until the cavity is largely obliterated, and a new vesicle is formed between the primitive lens and the anterior wall of the primary optic vesicle. This new vesicle, which is known as the ocular cup, or secondary optic vesicle, subsequently becomes the vitreous chamber.

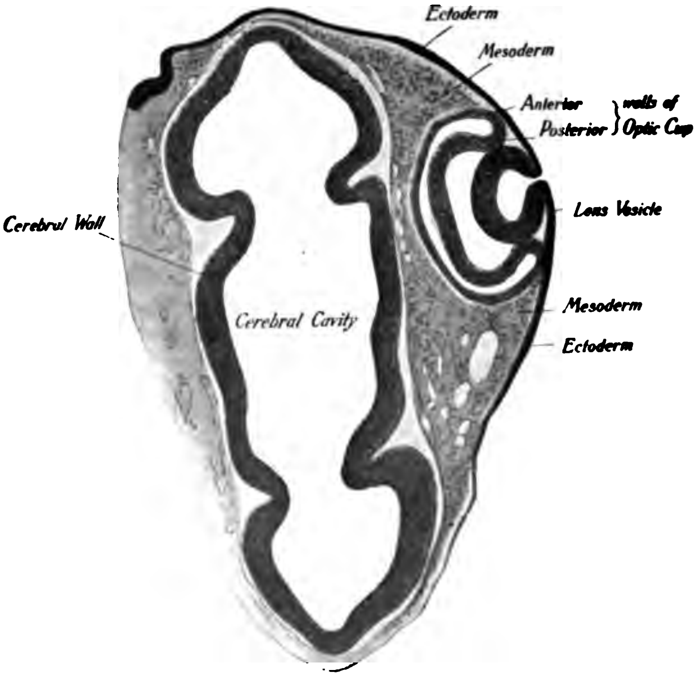

FIG. 1.—EMBRYONIC EYE OF A CHICK. (Fick.)

When the invagination of the ocular vesicle by the rudimentary lens takes place, the lens fills the cavity of the vesicle completely, no vitreous as yet existing. The vitreous, in its earliest stages, is essentially connective tissue derived from the middle germinal layer, or mesoderm, which surrounds the optic vesicle.

The ocular vesicle not only undergoes invagination at its anterior pole, but also along its inferior border, as well as along the optic stalk. As a consequence of this process, the vesicle is not completely closed. This cleft, or defect, known as the chorioidal fissure, is continued backward upon the pedicle of the ocular vesicle (the optic nerve) in the form of a groove or furrow.

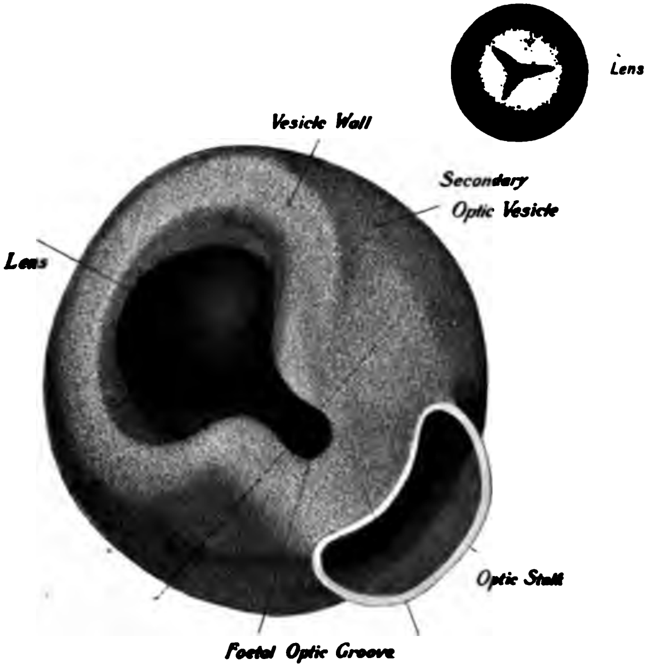

FIG. 2.—DEVELOPMENT OF THE LENS. (Fick.)

The mesoderm, pushing its way through the chorioidal fissure, grows into the interior of the eye between the lens and retina, and becomes converted into the vitreous. In the course of normal development, the margins of the chorioidal fissure are united before birth, so that a closed vesicle is again formed. In some rare instances, however, the fissure is imperfectly closed, resulting in a defective inferior border of the iris chorioid, or optic nerve (coloboma).

By the union of the edges of this fissure, the vitreous is isolated from the surrounding mesoderm, which goes to form the uveal tract, the sclera, and the cornea.

The edges of the cleft in the optic nerve, corresponding to the chorioidal fissure, also unite, inclosing a certain portion of mesodermic tissue. This develops, after the third month, into the central vessels of the optic nerve, which are continued forward into the vitreous.

The retina is also developed from the primary optic vesicle, the posterior wall becoming reduced in thickness, and its cells assuming a cuboidal shape with pigmented granules. This is the rudimentary pigment layer of the retina. The invaginated anterior wall, however, becomes thicker, owing to an increase in the number of its cells, which are of the spindle-shaped variety. This layer differentiates into two kinds of cells, one comprising the sustentacular elements (Müller's fibres), and the other the nerve cells.

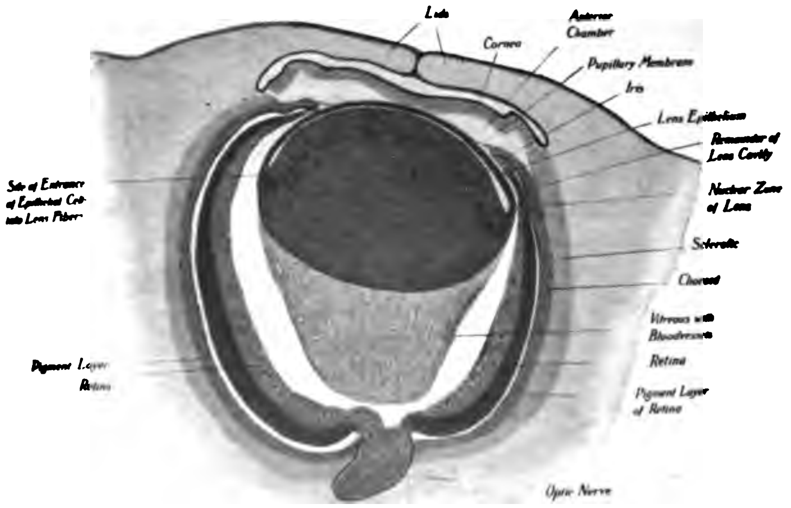

FIG. 3.—DEVELOPMENT OF THE EYE. (Fick.)

From the sustentacular cells, Müller's fibres and their branches, together with the inner and outer limiting membranes, various nervous elements, such as the bipolar cells, the layer of ganglion cells, etc., take their origin.

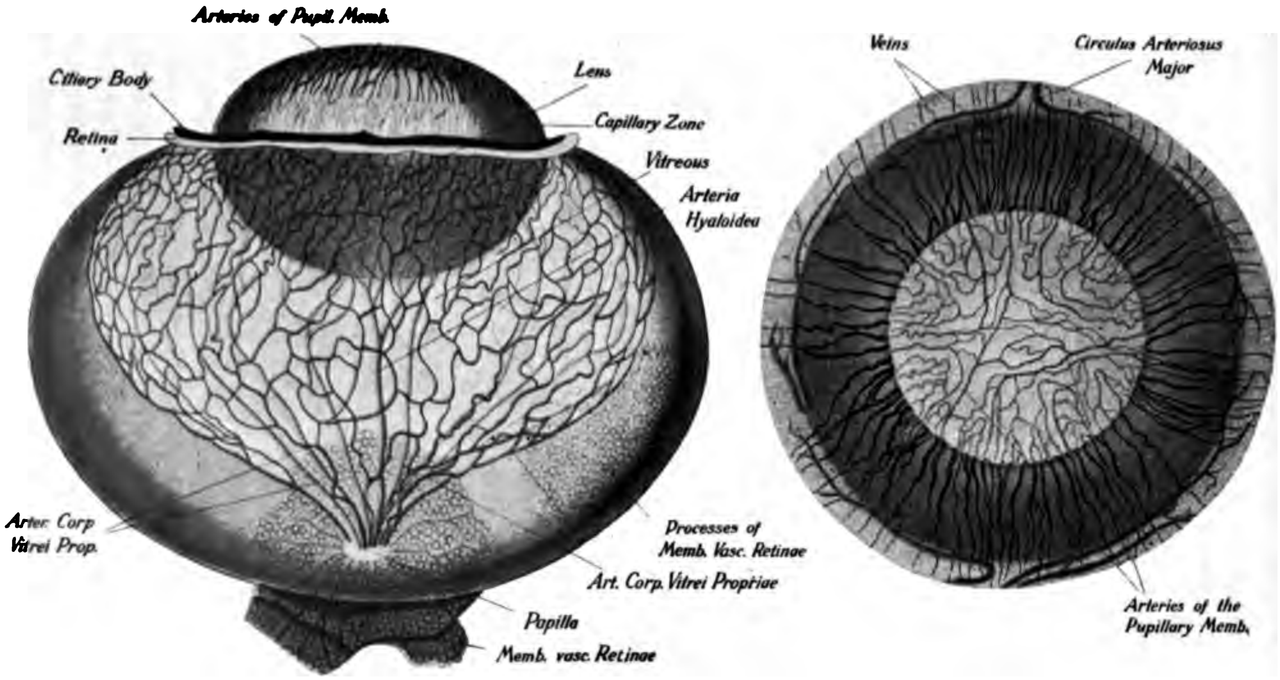

FIG. 4.—THE EMBRYONIC VASCULAR SYSTEM OF THE EYE. (Fick.)

The rods and cones, which are incompletely developed at birth, grow from the outer extremities of the rod- and cone-visual cells and project through the external limiting membrane. The macula lutea also remains undeveloped until after birth.

The retinal nerve-fibres are the last to develop, and their derivation has not been indisputably determined. It is assumed, however, that they are developed from the neuroblasts of the retina itself, and from those of the interbrain. (They are the axones of the cells of ganglion-cell layer of the retina.—Müller.)

On close examination the vessels of the eye, in its embryonic stage of development, will be seen to be arranged as follows:

The central portion of the vitreous is occupied by a small canal through which the arteria centralis, as the hyaloid artery, continues its course to the posterior wall of the lens. Small lateral branches of this artery, forming an arterial network, are given off in the periphery of the vitreous and margin of the lens. The blood-vessels of the vitreous disappear several months before birth, the hyaloid artery being replaced by a canal (canal of Stilling) which persists in adult life.

The crystalline lens is derived from the ectodermic vesicle, previously described, the walls of which vary greatly in thickness. The anterior lamina is retained as a part of the anterior lens-capsule and is comparatively thin. The posterior lamina is provided with cells, the elongation and subsequent transformation of which furnish the lens-fibres and greater portion of the lens-substance. The anterior and posterior capsules of the lens are derived from the mesoderm and are therefore genetically distinct from the lens.

The fœtal lens is surrounded by a vascular membrane, derived from the mesoderm, known as the *tunica vasculosa lentis*, which in the region of the pupil is called the ***pupillary membrane*** (*membrana pupillaris*) and the remaining portion of which is designated the *capsular membrane* (*membrana capsularis*). This vascular membrane, from which the developing lens derives its nutrition, disappears two months preceding birth. Small portions of this tunic in the pupillary area are, however, quite frequently seen in the newly born as a thin membrane closing the pupil, causing a congenital defect of the eye known as *atresia pupillæ congenita*.

As already stated, the cornea, sclera, and uveal tract are derived from the mesoderm surrounding the fœtal ocular vesicle. This mesoderm may be considered as consisting of an outer and inner layer of cells, the cornea and sclera being a product of the former, and the uvea of the latter.

The chorioid is mesodermic in origin, appearing first as a fibrous tunic. The vascular networks are not produced until comparatively late.

The iris and ciliary body, the most anterior portions of the uvea, arise from that layer of mesoderm which covers the anterior wall of the vesicle, and which also furnishes the inner lining for both these structures.

The eyelids are formed at the end of the third month as folds of ectoderm containing mesodermic tissue; this mesodermic tissue grows out above and below the skin surrounding the eye until the free margins come into immediate contact and fuse in front of the globe. Separation of the eyelids takes place shortly before birth.

The conjunctiva develops from the ectoderm which covers the surface of the embryo.

The lacrymal gland takes its origin from small epithelial islands of the primitive conjunctiva, growing into the orbital tissue.

The lacrymal canal arises as a thickening of the ectodermic cells at the bottom of the groove, which extends upward towards the eye between the fronto-nasal and superior maxillary processes. A hollowing out of this thickening takes place, the edges or lips meeting over the groove, resulting in complete isolation of the canal from the surface.

To summarize, the three essential organs of the eye—the optic nerve, the retina, with its two layers, the retina proper, and the pigmented layer, and the lens—are the first parts of the eye to develop. The remaining structures, the sclerotic, the vitreous, the aqueous humour, the iris, the muscles of accommodation, etc., either grow into or around the ball or optic cup secondarily.

CHAPTER II

ANATOMY OF THE EYE

THE human eyeball is nearly spherical in form, measuring more in its transverse than in its antero-posterior or vertical diameters. It is situated in the orbital cavity, in the anterior part of the skull, and is protected anteriorly by the eyebrow, eyelashes, and eyelids, and posteriorly by adipose tissue. It is acted upon by muscles, and is supplied by blood-vessels and nerves.

The orbits are four-sided pyramidal bony cavities, with their bases pointing anteriorly and apices posteriorly. Each orbital cavity is formed by seven bones—viz.:

Superior maxillary.
Malar.
Palate.
Frontal.
Sphenoid.
Ethmoid.
Lacrymal.

Of these, the frontal, sphenoid, and ethmoid are common to both orbits. For convenience of study, the bones entering into the formation of the orbital cavity may be arranged in the following manner:

1. *Floor.*
   Orbital plate of superior maxillary bone; portion of the malar; orbital process of palate bone.
2. *Roof.*
   Orbital plate of frontal mainly; at apex, the lesser wing of sphenoid.
3. *Inner Wall.*
   Os planum of ethmoid; orbital surface of lacrymal; orbital portion of sphenoid posteriorly; nasal process of superior maxillary anteriorly.

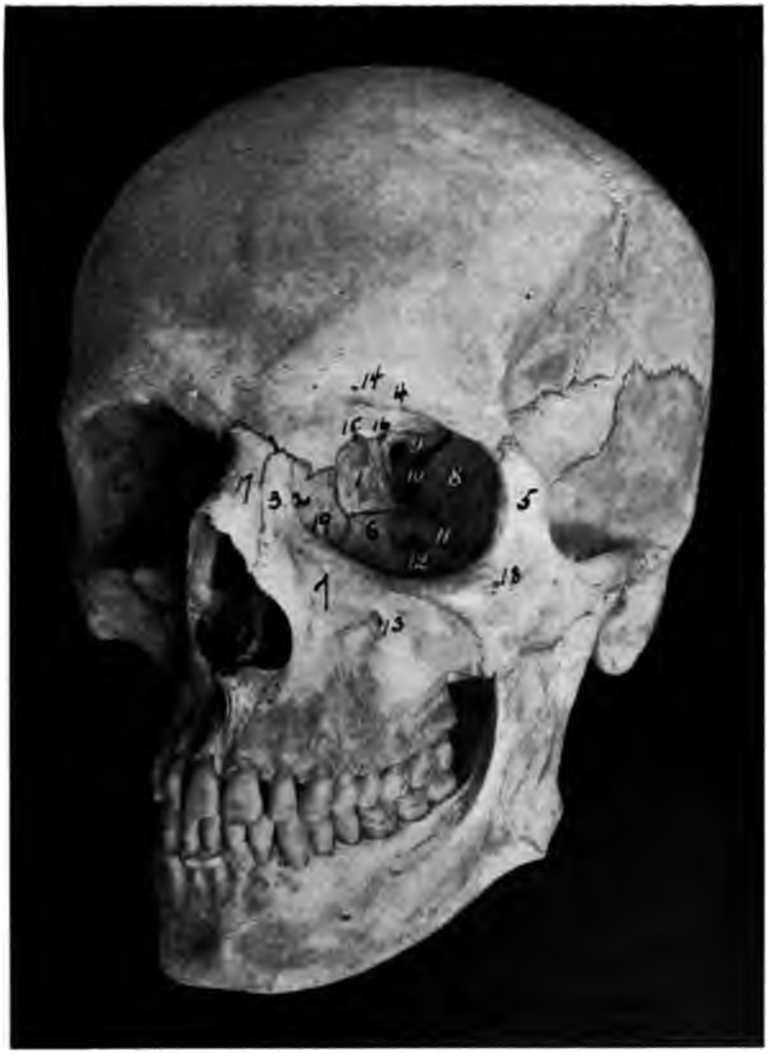

FIG. 5.—SKULL AND ORBITS. (Cryer.)

1, Os planum of ethmoid; *2*, lacrymal; *3*, nasal process of superior maxillary; *4*, frontal bone (supra-orbital ridge); *5*, malar (part of infra-orbital ridge); *6*, orbital process of superior maxillary; *7*, superior maxillary (part of infra-orbital ridge); *8*, orbital process of sphenoid; *9*, lesser wing of sphenoid and optic foramen; *10*, sphenoid fissure or anterior lacerated foramen; *11*, spheno-maxillary fissure; *12*, infra-orbital groove; *13*, infra-orbital foramen; *14*, supra-orbital foramen; *15*, anterior ethmoidal foramen; *16*, posterior ethmoidal foramen; *17*, nasal bone; *18*, malar foramen; *19*, lacrymal canal.

4. *Outer Wall.*
   Posteriorly, anterior surface of greater wings of sphenoid; anteriorly, orbital process of malar.

The thinnest portions of the orbit are the roof and nasal wall; the inner wall is somewhat thicker, and the outer is from five to six times as thick as the inner wall. Each orbital cavity has nine openings—five foramina, two canals, and two fissures. These openings are as follows:

1. *Optic Foramen.*
   Communicating with cranial cavity and transmitting optic nerve and ophthalmic artery.
2. *Infra-orbital Canal.*
   Transmitting the infra-orbital vessels and nerve.
3. *Supra-orbital Foramen.*
   At the junction of the inner and middle thirds of the upper circumference, transmitting the supra-orbital artery, veins, and nerve.
4. *Malar Foramen.*
   Transmitting temporal and malar branches of orbital nerve.
5. *Ethmoidal Foramina* (Anterior and Posterior).
   The former transmitting the anterior ethmoidal vessels and nasal nerve; the latter the posterior ethmoidal vessels.
6. *Sphenoidal Fissure* (Anterior Lacerated Foramen).
   Communicating with cranial cavity, and transmitting principally the third and fourth nerves; three branches of the ophthalmic divisions of fifth; sixth nerve; and ophthalmic vein.
7. *Spheno-maxillary Fissure.*
   Communicating with spheno-maxillary and zygomatic fossæ, and transmitting infra-orbital vessels and nerves; ascending branches from spheno-palatine or Meckel's ganglion and superior maxillary nerve, and its orbital branches.
8. *Lacrymal Canal.*
   Lacrymal fossa with the nose; the lacrymal canal is occupied by the lacrymal sac and duct, through which the tears are transmitted to the nose.

Within the orbit the eye rests upon a bed of fat, from which it is separated by a membranous sac—the capsule of Tenon.

For convenience in describing the eye, the following terms are in common use:

a. Diameters.—Antero-posterior, transverse, vertical, and oblique. (In the adult these diameters are .950 inch, .925 inch, .915 inch, and .943 inch, respectively.)

b. The anterior and posterior poles are the geometric centres of the cornea and fundus, respectively.

c. The optic axis is a straight line passing through the anterior and posterior poles of the eye.

d. The nodal point is an imaginary point—the centre of curvature of the refracting media—where all the luminous rays pass without deviation.

e. The line of vision or visual axis is an imaginary line passing through the nodal point, which connects the point of fixation with the fovea centralis. It usually lies to the outer side of the centre of the pupil. As it passes through the cornea it forms with the optic axis the visual angle—an angle of from 3 to 7 degrees.

f. The equatorial plane is an imaginary plane passing through the centre of the eyeball at right angles to the optic axis, dividing the globe into anterior and posterior hemispheres.

g. The equator is the line passing around the globe through the points cut by the equatorial plane.

h. Meridional planes are imaginary antero-posterior planes which are at right angles to the equatorial plane, both in their vertical and horizontal direction.

i. Meridians are lines passing through points upon the surface of the globe, where it is cut by the meridional planes.

Capsule of Tenon.—The capsule of Tenon (tunica vaginalis oculi) is a fascia between the eyeball and the walls of the orbit, isolating the eyeball and allowing free movement. It is continuous in front with the subconjunctival connective tissue, and behind with the dura mater, through the sphenoidal fissure and optic foramen. It consists of two layers: a visceral layer, investing the posterior portion of the eyeball from the ciliary margin of the cornea backward to the entrance of the optic nerve, and a parietal layer, lining the cushion of fat on which the eye rests.

The inner aspect is lined with flattened endothelial cells, and incloses a lymph space, communicating with the subdural and subarachnoidean lymph spaces of the optic-nerve sheath. It supports the lacrymal gland, is strengthened by numerous fibrous bands, and is pierced by the ocular muscles near their insertions, inclosing them in imperfect sheaths.

The tunica vaginalis is divided by some anatomists into two parts, the *capsule of Bonnet* being the name given to the portion posterior to the entrance of the tendons, and the *capsule of Tenon* being applied to the anterior socket-like half.

Eyeball.—The eyeball is composed of segments of two spheres of different size. The larger segment (*sclerotic*), which is opaque, forms about $\frac{5}{6}$ of the globe, and is designed for the protection of its contents; the smaller segment (*cornea*) is transparent and is implanted upon the larger, with which it is continuous in front. The optic nerves enter the eyeballs a little to their nasal side, in the direction of the axes of the orbit, which are not parallel with the axes of the eyeball, but are directed outward.

The eyeball is composed of three tunics or coats:

1. Sclerotic and cornea;
2. Chorioid, iris, and ciliary body;
3. Retina.

There are also three humours, which, together with the cornea, form the refracting media of the eye. These are:

1. Aqueous humour.
2. Crystalline lens (and capsule).
3. Vitreous humour, or body.

There are likewise three chambers—namely:

1. Anterior chamber.
2. Posterior chamber.
3. Vitreous chamber.

Sclerotic Coat.—The sclerotic coat, so called from its extreme density, is thicker behind ($\frac{1}{25}$ of an inch) than in front ($\frac{1}{60}$ of an inch), and presents two surfaces for study: the external and internal.

The external surface is smooth and white, and to it are attached the various muscles of the eye.

The internal surface is grooved for the passage of the ciliary nerves, and is connected to the chorioid by a fine cellular areolar layer—the *lamina fusca.* Posteriorly, and a little to the nasal side, the sclerotic is pierced by the optic nerve. Where the neurilemma of the fibres ceases, as the nerve penetrates this coat, the nerve is constricted by the *lamina cribrosa,* a sieve-like continuation of the sclerotic. One of the openings in the lamina cribrosa, larger than the rest, known as the *porus opticus,* transmits the *arteria centralis retinæ;* the others transmit the ciliary vessels and nerve. The sclerotic is continuous in front with the cornea, overlapping it a little on its outer margin.

In structure it is a strong, white, fibrous tissue with a small quantity of elastic fibres and connective-tissue corpuscles. It contains very few, if any, nerves.

Cornea.—The cornea is the convex, transparent, nearly circular tissue, forming the anterior $\frac{1}{6}$ of the globe. In mature individuals it is from $\frac{1}{25}$ to $\frac{1}{32}$ of an inch in thickness. Its thickness at the periphery is 1.12 millimetre, the curvature of the posterior surface more nearly approximating to that of a true sphere than the anterior. It is a trifle greater in its transverse than its vertical diameter, and, owing to the overlapping of the sclerotic above and below, the posterior surface slightly exceeds the anterior. It is composed of layers, as follows:

1. Conjunctival epithelium.
2. Anterior elastic lamina (Bowman's membrane).
3. Cornea proper.
4. Posterior elastic lamina. Membrane of Descemet.
5. Endothelial lining.

The conjunctival epithelium consists of several layers of cells (columnar, polyhedral, and squamous) covering the anterior surface of the cornea, and continuous with the conjunctiva.

The cornea proper is made up of a transparent fibrous structure identical with the sclerotic. It consists of about sixty laminæ, connected by a cement substance inclosing corneal spaces, each of which contains a corneal corpuscle. The anterior elastic lamina is the outer epithelial layer.

The posterior elastic lamina consists of an elastic, homogeneous membrane, internal to the proper structure of the cornea. It constitutes, with the endothelial lining of the aqueous chamber, the membrane of Descemet or Demours.

The structure of the cornea is non-vascular, being nourished by channels representing lymphatic vessels, and continuous with the corneal spaces. Branches from the ciliary nerves are numerous. They form, between the outer surface of the cornea proper and the epithelial covering, the ***subepithelial plexus,*** from which is given off the *intra-epithelial plexus.*

Chorioid.—The second tunic or uveal tract consists of the chorioid; the ciliary body, which includes the ciliary ring, the ciliary processes, and the ciliary muscle; and the iris. The latter is a circular muscular septum suspended behind the cornea, and presenting a large central, circular aperture—the pupil. The iris bears the same relation to the chorioid that the cornea bears to the sclerotic.

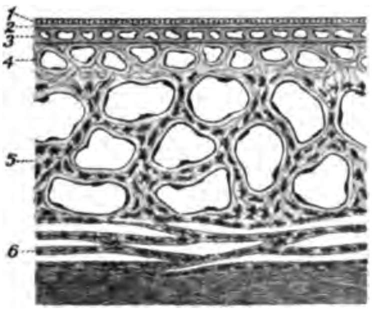

FIG. 6.—CHORIOID. (Magnus.)

1, Retinal pigment epithelium ; *2*, lamina vitrea ; *3*, membrana Ruyschii ; *4*, Sattler's layer, or chorio-capillaris ; *5*, tunica vasculosa Halleri ; *6*, membrana fusca.

The chorioid is a dark, reddish-brown, highly vascular tunic or membrane, lining the sclerotic coat from the optic nerve to the ciliary ligament, where it becomes continuous with a number of radial folds or processes, called the ciliary processes. Its outer surface is in contact with the inner coat of the sclerotic, to which it is attached by the ***membrana fusca,*** and on its inner surface the retina is supported.

The structure of the chorioid consists chiefly of a dense capillary network.

The chorioid proper consists of an external and an internal layer, and is separated from the sclerotic by the *lamina suprachorioidea,* or subscleral lymph space, which is continuous with the *lamina fusca* of the sclerotic. On the inner surface of the chorioid is a very thin, structureless membrane—the *vitreous membrane* (*lamina vitrea*). This is closely connected with the stroma of the chorioid and separates the ***membrana Ruyschii*** from the pigmentary layer of the retina.

The external layer or stroma layer consists of a capillary network, derived from the larger branches of the short ciliary arteries, inclosing between the meshes large, star-shaped, pigment cells, which are connected by a delicate stroma. The veins which make up the principal part of the outer layer form the ***venæ vorti-***

cosæ. They converge at four or five equidistant points and emerge through the sclerotic midway between the optic nerve and the margin of the cornea.

The internal layer, or chorio-capillaris, is composed of a finer capillary network, derived from the short ciliary arteries, and is continuous in front with the vessels of the ciliary processes. It is called the *tunica Ruyschiana.*

The blood supply of the chorioid is derived through the short posterior ciliary arteries (principally in the external layer) and recurrent branches of the long anterior and posterior ciliary.

The veins converge from the venæ vorticosæ to form four or five trunks, which pierce the sclerotic midway between the optic nerve and corneal margin to join the cavernous sinus.

The nerves are the long and short ciliary.

The ciliary processes are a series of 60 to 80 pigmented vascular processes, arranged circularly around the lens behind the iris, and composed of two internal layers of the chorioid, folded inwardly. They are continuous anteriorly with the iris, and are connected posteriorly with the suspensory ligament of the lens.

The structure is similar to that of the chorioid.

The ciliary muscle is a grayish, circular band, of unstriated fibres, attached to the fore part of the chorioid. It consists of three sets of fibres: the meridional fibres, the external radiating fibres, and the internal circular fibres. The meridional fibres arise from the junction of the sclerotic and cornea, and are inserted into the chorioid opposite the ciliary processes; with the radial fibres they constitute the *tensor chorioidea*; the latter fibres pursue a circular course around the insertion of the iris. The external radiating fibres arise from the canal of Schlemm and pass towards the centre of the eye.

The ciliary muscle is the muscle of accommodation; its contraction, by drawing on the ciliary processes, relaxes the suspensory ligament of the lens, and permits the anterior surface of the lens, by its inherent elasticity, to become more convex.

Iris.—The iris is a thin circular curtain, suspended in the aqueous humour, between the lens and cornea, and perforated by a circular aperture—the pupil.

Its circumference is connected with the chorioid and also, by means of the ciliary ligament, with the sclerotic and cornea. The sclerotic contains in this position, near its junction with the

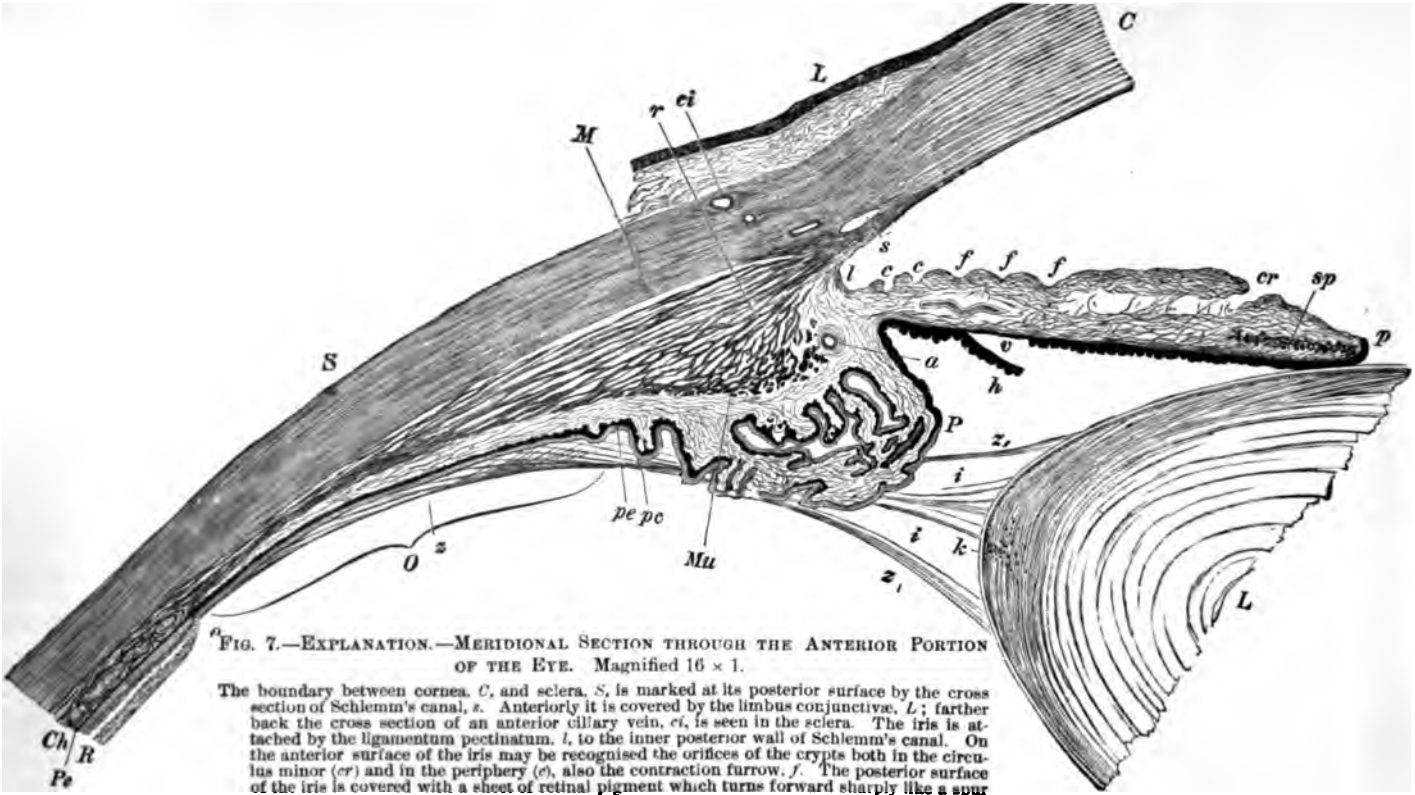

FIG. 7.—EXPLANATION.—MERIDIONAL SECTION THROUGH THE ANTERIOR PORTION OF THE EYE. Magnified 16 × 1.

The boundary between cornea, *C*, and sclera, *S*, is marked at its posterior surface by the cross section of Schlemm's canal, *s*. Anteriorly it is covered by the limbus conjunctivæ, *L*; farther back the cross section of an anterior ciliary vein, *ci*, is seen in the sclera. The iris is attached by the ligamentum pectinatum, *l*, to the inner posterior wall of Schlemm's canal. On the anterior surface of the iris may be recognised the orifices of the crypts both in the circulus minor (*cr*) and in the periphery (*c*), also the contraction furrow, *f*. The posterior surface of the iris is covered with a sheet of retinal pigment which turns forward sharply like a spur at the pupillary margin, *p*. At one spot the posterior layer, *h*, of the pigment has separated so that the anterior layer, *v*, can be seen isolated. Close to the pupillary margin, the cross section, *sp*, of the sphincter pupillæ is visible. From the posterior wall of Schlemm's canal rises the ciliary muscle, consisting of longitudinal fibres, *M*, and circular fibres, *Mu*; the transition from one portion to another is effected by the radial fibres, *r*. At the anterior margin of the circular portion is seen the cross section of the circulus anteriosus iridis major (*a*). Upon the ciliary muscle are situated the ciliary processes, *P*, which are covered by the two layers of the pars ciliaris retinæ—namely, by the pigmented cellular layer, *pe*, which is the continuation of the pigment epithelium, *Pe*, and by the non-pigmented layer, *pc*, the continuation of the retina proper, *R*. The flat part of the ciliary body, the orbiculus ciliaris, *O*, extends to the ora serrata, *o*, where the chorioid, *Ch*, and the retina, *R*, begin. Upon the orbiculus lie the fibres of the zonule of Zinn, z, which farther forward pass into the free portion, z_1, of the zonula and there inclose the cavity of the canal of Petit, *i*. The lens, *L*, shows at its equator, besides the attachments of the zonular fibres, the cross section, *k*, of the ring of nuclei.

cornea, a circular canal (lymph channel, or venous sinus), the *sinus circularis iridis,* or *canal of Schlemm.*

The circumference of the iris is also connected in front with the cornea by the *ligamentum pectinatum iridis,* derived from the membrane of Descemet.

The iris is composed of four elements, as follows:

1. Polyhedral cells on a basement membrane; this layer is continuous with the epithelial layer of the membrane of Descemet.
2. The stroma, which consists of bundles of fibrous tissue and cells.
3. Involuntary muscular fibres:
    a. Circular fibres, forming the sphincter of the pupil.
    b. Radiating fibres, forming the dilator of the pupil.
4. Pigment, consisting of polyhedral or round pigment cells, distributed for the most part on the posterior surface, which, from its deep purple tint, has been called the uvea.

The arteries are derived from the long and anterior ciliary and from the ciliary processes (from the short ciliary).

The veins join those of the ciliary processes and anterior ciliary veins.

The nerves are the long ciliary from the nasal branch of the ophthalmic (first division of the fifth), and ciliary branches from the lenticular or ophthalmic ganglion.

The circular fibres are supplied by the fibres from the third nerve or motor oculi; the radiating fibres are supplied by the sympathetic.

The *membrana pupillaris* is a delicate vascular membrane, closing the pupil in the fœtus, and continuous at its margin with the iris. It usually disappears about the eighth month. It occasionally persists, however, and may cause blindness, or at least partial obstruction of vision.

Retina.—The retina is a delicate, white, nervous membrane, the expansion of the optic nerve. Externally it is in contact with the chorioid, and internally with the vitreous body. It terminates in front near the ciliary ligament in an irregular margin, the *ora serrata,* but is prolonged forward as the *pars ciliaris* and *pars iridica* to the margin of the pupil. Its internal surface, at a point corresponding to the axis of the eyeball, presents a small, round, elevated spot of yellowish colour, the *macula lutea,* or yellow spot of Sömmering. In the centre of the macula lutea is a central depression, the *fovea centralis*, the region of most acute vision. Near a point corresponding to the axis of the orbit and about $\frac{1}{10}$ of an inch to its nasal side the optic nerve makes its entrance through the *porus opticus*, an oval, bluish-white depression, with distinct, often pigmented margins. This region, which is destitute of vision, is the optic disk—often called the *blind spot*. The centre of the nerve is pierced by the *arteria centralis retinæ*, which gives off branches to the nasal, upper, and lower sides of the macular region.

The structure of the retina is exceedingly complex, and when examined microscopically is seen to be made up of ten layers from within outward, as follows:

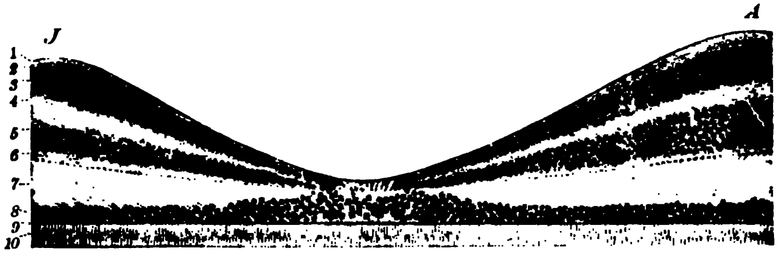

FIG. 8.—THE RETINA AND MACULA LUTEA. (Greeff.)

1, Membrana limitans interna; *2*, nerve-fibre layer; *3*, ganglion-cell layer; *4*, inner molecular layer; *5*, inner nuclear layer; *6*, outer molecular layer; *7*, outer nuclear layer; *8*, membrana limitans externa; *9*, layer of rods and cones; *10*, pigment epithelial layer.

1. The *membrana limitans interna*, which is in contact with the hyaline membrane of the vitreous humour, is the most internal layer of the retina. It is formed by the expanded bases of Müller's fibres, from which fibres the *membrana limitans externa* is also derived.

2. The *fibrous layer* made up of nerve-fibres—the terminal optic nerve-fibres.

3. The *vesicular layer*, or *ganglion-cell layer*, composed of a single layer of large, flask-shaped ganglionic cells. In the macular region these cells become more numerous, until at the margin of the fovea they are six or eight deep. Their axones are the fibres of the optic nerve.

4. The *inner molecular layer* is composed of a layer of granular-like structure forming a reticulum composed of networks of neuroglia and the branched processes of various nerve-cells of

adjacent layers. This layer incloses minute granules of unknown nature.

5. The *inner nuclear layer* is composed of three sets of nuclear bodies, the first resembling bipolar nerve-cells, the second a stratum of cells without branches, and the third continuous with the radiating fibres or fibres of Müller.

6. The *outer molecular layer* is much thinner than, but closely resembles, the inner molecular layer, from which it differs, however, in the fact that it contains branched stellate cells.

7. The *outer nuclear layer* is composed of several layers of nuclear cells, separable into two kinds: the *rod granules* and the *cone granules,* both continuous with the rods and cones of Jacob's membrane, being the nuclei and the modified bodies of the specialized epithelial cells, of which the rods and cones are the processes.

8. The *membrana limitans externa,* like the internal limiting membrane, is derived from the radiating fibres or fibres of Müller.

9. *Jacob's membrane,* or the layer of rods and cones, consists of two distinct kinds of elements, the rods and cones, which are distributed alternately throughout this layer, the rods being much more numerous.

The rods are solid, stand perpendicularly to the surface, and consist of two portions: the outer portion striated and the inner granular.

The cones are flask-shaped, with their pointed extremities towards the chorioid. They also consist of two portions: the outer portion striated and the inner granular.

The layer of rods and cones, together with the rod and cone "granules" of the outer nuclear layer constitute one continuous layer of neuro-epithelium.

10. The *pigmentary layer,* which was formerly described as a layer of the chorioid, has received the name *tapetum nigrum.* It consists of a single layer of hexagonal, epithelial cells loaded with pigment granules. In many mammals the pigment particles are absent, but their reflex is substituted by the *tapetum lucidum,* an iridescent lustre supplied by the chorioid.

The radiating fibres, or fibres of Müller, are derived from a part of the original epithelial cells of the optic cup. They serve to connect the various layers of the retina constituting their stroma, and, as has been already mentioned, form the external and internal limiting membranes.

The structure of the retina undergoes important alterations to form the macula lutea. One of the most striking changes, perhaps, is the diffuse yellow pigmentation, limited to this area, which serves in the recognition of this region in examination by the ophthalmoscope.

Histologically, there is no continuity of the nerve-fibre layer; Jacob's membrane is represented by the cones alone; the ganglion-cells of the vesicular layer undergo extraordinary development and form several layers of cells, and the outer nuclear layer consists only of cone-fibres that have become elongated and curved.

The fovea centralis results from the hollowing out of the macula in consequence of the thinning and later disappearance of some of the retinal layers. The cones of Jacob's membrane, the external nuclear layer, and the internal granular layer constitute the remaining portions of the retina in this situation. Within a central area of 5 millimetres width there is an entire absence of blood-vessels. The fovea centralis is devoid of pigment.

The arteria centralis retinæ supplies the retina only as far as the inner nuclear layer.

Aqueous Humour.—The aqueous humour is a transparent, alkaline, serous substance or fluid, small in quantity—weighing 4 to 5 grains—which fills the anterior and posterior chambers of the eye. It is composed of water, 98.6 per cent, small quantities of solids, extractive matters, principally chloride of sodium, and proteids.

The *anterior chamber* is the space (about 2.7 millimetres in depth) between the iris and cornea.

The *posterior chamber* is the space, formerly described as existing between the anterior surface of the lens and the iris. It amounts to a space only between the peripheral part of the iris, the suspensory ligament, and the ciliary process, the lens and iris being in contact at the posterior surface.

Communication between these chambers is free in the adult through the pupil, but in the fœtus the pupillary membrane serves to separate them until its disappearance at the seventh month.

Crystalline Lens.—The crystalline lens is a biconvex, transparent, elastic body inclosed in a capsule—which is connected laterally with the suspensory ligament—and surrounded by the ciliary processes. It is more convex on its posterior surface, the

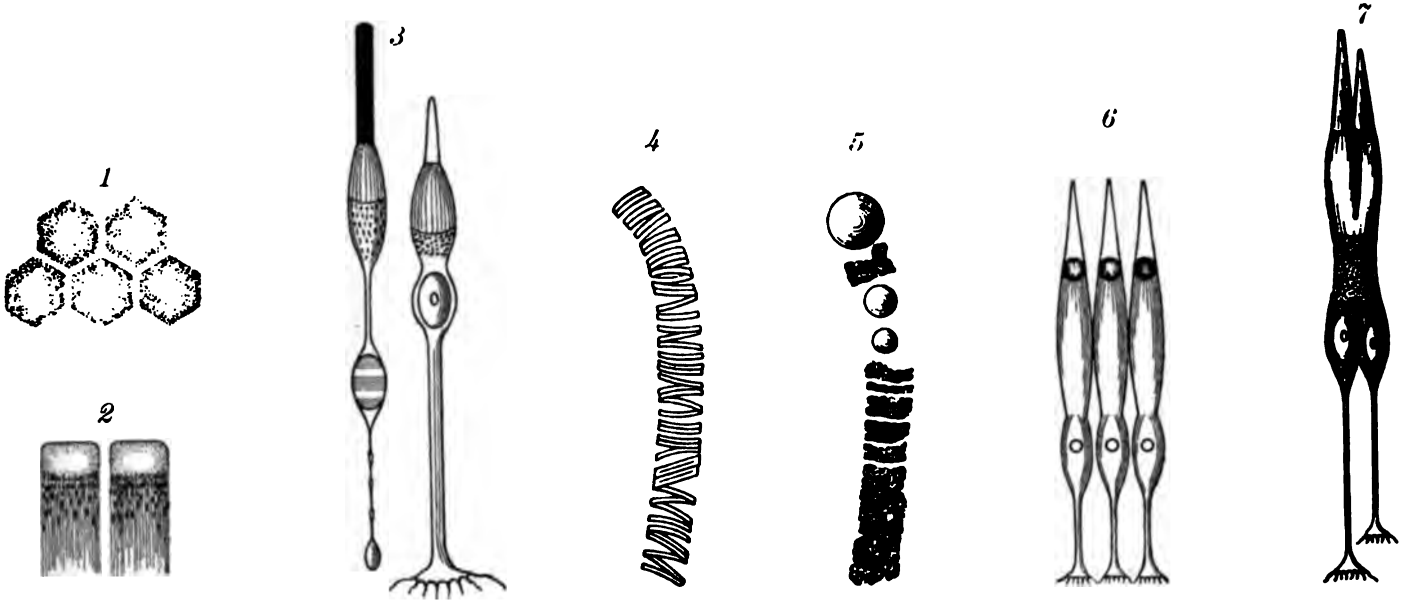

FIG. 9.—INDIVIDUAL RETINAL ELEMENTS. (Greeff.)

1, Hexagonal pigment epithelium; 2, longitudinal section of pigment epithelium; 3, 4, 5, 6, 7, rods and cones.

anterior surface having a radius of approximately 10 millimetres when accommodating for far vision and 6 millimetres for near, while the radius of the posterior surface under similar conditions is 6 millimetres and 5 millimetres respectively. The posterior surface of the lens rests in the hyaloid fossa of the vitreous.

The lens measures about $\frac{1}{3}$ inch in transverse diameter, about $\frac{1}{4}$ inch in antero-posterior diameter, and weighs from 0.2 to 0.25 gramme.

Its index of refraction increases from the periphery to the centre, the average being 1.4371 (Helmholtz).

It is composed of about 60 per cent water; soluble albuminous matter 35 per cent; insoluble albuminous matter 2.5 per cent; cholesterin and fat 2 per cent.

The structure of the lens consists of concentric laminæ, made up of hexagonal prisms, about $\frac{1}{5000}$ inch in breadth, united laterally by dentated margins and curving round the borders of the lens. The laminæ are arranged into three triangular segments.

The central portion, or nucleus, is unstriated, while the fibres of the outer layer each contain a nucleus and form the cortex.

The *capsule of the lens* is a transparent, elastic, brittle membrane inclosing the lens, and held in position by the suspensory ligament. Its anterior layer is thicker than the posterior, and is attached to the lens by a layer of polygonal, nucleated cells, which break down after death to form the *liquor Morgagni.* The lens fibres are believed to be derived from these cells. Epithelial cells are absent on the posterior surface.

The *canal of Petit* is about $\frac{1}{10}$ of an inch in diameter, traversing the circumference of the lens capsule. Its base is formed by the capsule, and it is bounded in front by the suspensory ligament, and behind by the vitreous humour.

The *suspensory ligament,* or *zonule of Zinn,* is a thin, transparent structure, extending from the margins of the hyaloid fossa, where it is continuous with the hyaloid membrane, to the ciliary processes of the chorioid.

The crystalline lens is devoid of blood-vessels and receives its nourishment from the ciliary body. In the fœtus, a small branch of the arteria centralis retinæ is continued through the vitreous to the posterior capsule of the lens, where its branches radiate and join with those of the iris and pupillary membrane.

In the fœtus the crystalline lens is almost spherical in form, slightly reddish in tint, imperfectly transparent, and extremely soft. In the adult it is more firm, colourless, transparent, and convex on both surfaces. As age advances it becomes flattened, less elastic, more dense, slightly opaque, and somewhat tinted.

Vitreous Humour.—The vitreous humour, or body, is a clear albuminous fluid which forms about ⅘ of the globe. It is hollowed out in front (hyaloid fossa) for the reception of the lens, and is inclosed in the hyaloid membrane. It is composed of water (98.5 per cent), with a few salts, and a little albumin. A delicate supporting reticulum extends through the vitreous, and this is particularly true in the fœtus. There is a complete absence of blood-vessels in the adult, nutrition being derived from the retinal vessels and ciliary processes.

The *canal of Stilling, canal of Cloquet,* or *hyaloid canal,* is a canal extending in the fœtus from the entrance of the optic nerve to the lens. It contains fluid, and is lined by a fold of hyaloid membrane. The canal of Stilling surrounds the atrophied remains of another canal, which, in the fœtus, transmits a minute artery from the central artery of the retina to the capsule of the lens.

The *hyaloid membrane* is a delicate, structureless membrane, investing the entire vitreous body, excepting its anterior surface. It sends fibrous septa into the vitreous, and at the pars ciliaris retinæ divides into two layers, the anterior forming the suspensory ligament, and the posterior passing over the front of the vitreous.

Muscles of the Eyeball.—The eyeball or globe is moved in various directions by the acfion of its muscles.

The muscles which effect its movements are the external rectus, the internal rectus, the inferior rectus, the superior rectus, the superior oblique, and the inferior oblique. These muscles are known as the extrinsic muscles of the eye.

Superior Rectus.—Origin: sheath of optic nerve and upper margin of optic foramen; insertion: into upper surface of sclerotic coat, 7.54 millimetres from corneal margin; action: rotates the eyeball upward, with a tendency to an inward deviation which is corrected by the inferior oblique; nerve: third cranial or oculomotor.

Inferior Rectus.—Origin: from lower and inner part of the optic foramen (*ligament of Zinn*): insertion: into lower surface of sclerotic, 7 millimetres from corneal junction; action: rotates the eyeball, with a tendency to an inward deviation which is corrected by the superior oblique; nerve: third cranial or oculomotor.

External Rectus.—Origin: by two heads—lower from ligament of Zinn and lower margin of sphenoidal fissure—upper from outer margin of optic foramen; insertion: into outer side of sclerotic 7.85 millimetres from corneal margin; nerve: sixth cranial or abducens. The ophthalmic vein, the third, nasal branch of fifth and sixth nerves pass between the two heads of this muscle.

Internal Rectus.—Origin: same as inferior rectus; insertion: into inner side of sclerotic 6.91 millimetres from corneal junction; action: rotates the eyeball inward; nerve: third cranial or oculomotor.

Superior Oblique.—Origin: from inner margin of optic foramen. Its tendon passes through a pulley near the internal angular process of the frontal bone. Insertion: into sclerotic between external and superior recti, midway between entrance of optic nerve and 17.9 mm. from the cornea; action: rotates eyeball on its antero-posterior axis; nerve: fourth cranial or patheticus.

Inferior Oblique.—Origin: orbital plate of superior maxillary; insertion: outer part of sclerotic near the insertion of the superior oblique, and between the external and superior recti; 17 to 19 mm. from corneal margin; action: rotates the eyeball on its antero-posterior axis; nerve: third cranial or oculomotor.

ARTERIAL, VENOUS, AND LYMPHATIC SYSTEMS OF THE EYE

1. **Arterial.**—*a.* The short ciliary arteries (six to twelve in number) enter through the sclerotic around the optic nerve to supply the chorioid and ciliary processes.

b. The long ciliary arteries (two in number) pierce the sclerotic, and run forward between the chorioid and sclerotic to the ciliary muscles, which they supply. Here they form an anastomotic circle about the iris.

c. The anterior ciliary arteries (five or six in number) enter the sclerotic in front, a short distance from the cornea, supply the ciliary processes, and anastomose about the iris.

d. The arteria centralis retinæ supplies the retina, dividing into four or five branches, which enter the structure as deeply as the inner nuclear layer.

Muscular branches (two) supply the eyeball muscles. These arteries constitute the ocular branches of the ophthalmic artery.

The orbital branches of the ophthalmic are the lacrymal, supra-orbital, anterior and posterior ethmoidal, palpebral, frontal, and nasal.

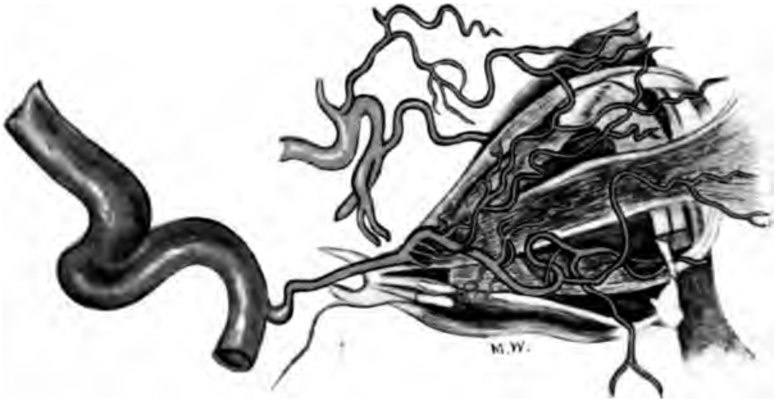

Fig. 10.—Ophthalmic Artery and its Distribution.

The lacrymal supplies the lacrymal gland and gives off one or two malar branches, one passing through a foramen in the malar bone, the other appearing on the cheek and anastomosing with the transverse facial.

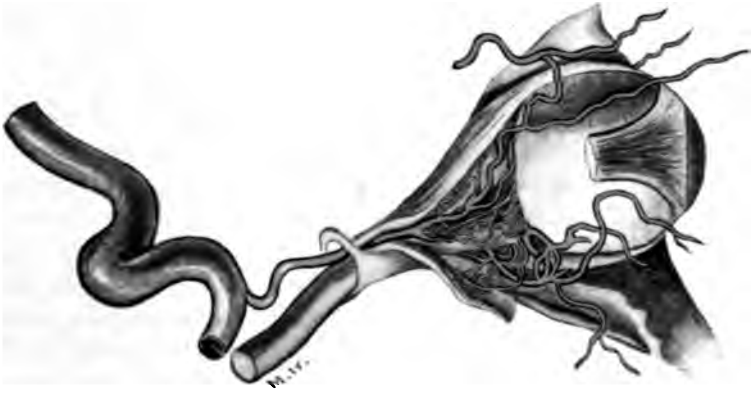

Fig. 11.—Deep Branches of Ophthalmic Artery.

The supra-orbital passes out through the supra-orbital foramen to supply the surrounding structures.

Posterior ethmoidal descends through the posterior ethmoidal foramen to the ethmoidal cells and adjacent parts.

Anterior ethmoidal passes through the anterior ethmoidal foramen and supplies the anterior ethmoidal cells and frontal sinus.

The palpebral arteries (two) supply the eyelids.

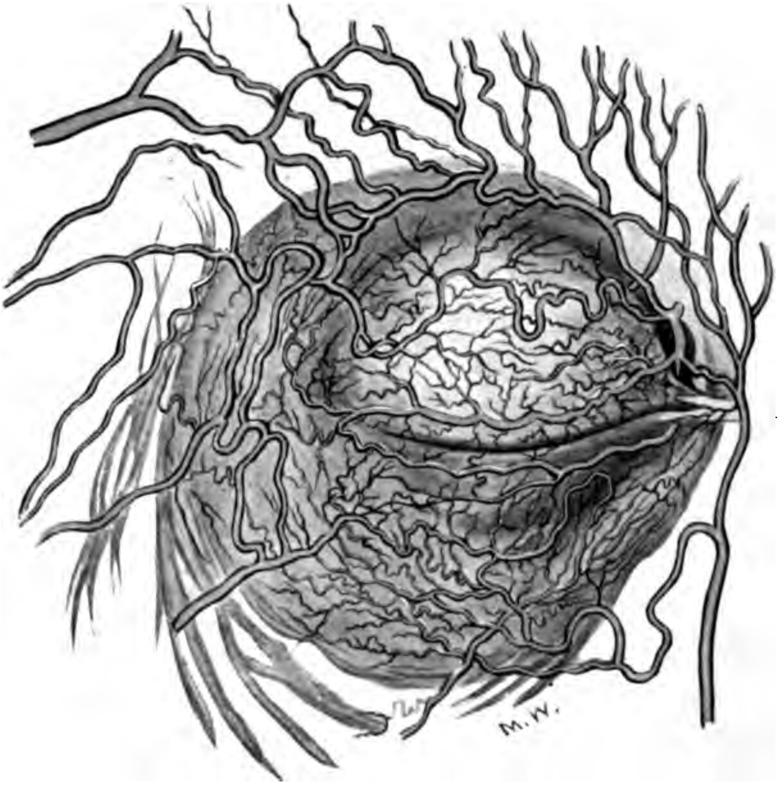

FIG. 12.—ARTERIAL SUPPLY OF THE EYELID.

The frontal artery supplies the skin and muscles of the forehead.

The nasal supplies the lacrymal sac and bridge of the nose.

The other arteries, supplying the eye and its appendages, are derived from the anterior cerebral branch of the internal carotid and the infra-orbital branch of the internal maxillary.

2. **Venous.**—The veins of the eyeball emerge through the sclerotic as the venæ vorticosæ, and unite with the other veins to form two main trunks—the superior and inferior ophthalmic

veins—which terminate in the cavernous sinus. The ophthalmic vein anastomoses freely with the internal angular vein, the commencement of the facial, at the inner angle of the orbit.

3. **Lymphatic.**—The lymphatic system, consisting of lymph channels and lymph spaces, is divided into the anterior lymphatic system and the posterior lymphatic system. The anterior portion of the lymphatic system occupies the anterior and posterior chambers of the eye, which communicate by means of the pupil.

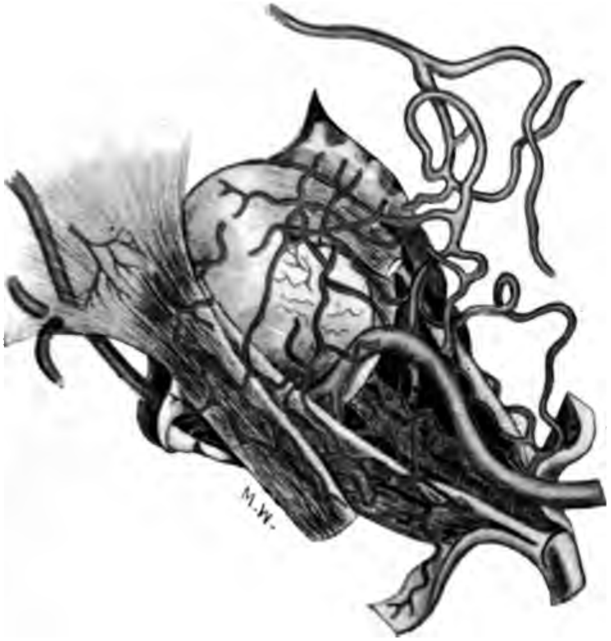

FIG. 13.—OPHTHALMIC VEIN.

The lymph exudes from the posterior surface of the iris and the anterior surface of the ciliary body, while a small portion is derived from the corneal endothelium and endothelium of the ciliary processes.

The lymph is discharged from the anterior chamber of the eye by being filtered through the *ligamentum pectinatum* into the *canal of Schlemm*, and thence into the episcleral lymph space, from which it is conveyed into the intracranial lymph spaces.

The posterior portion of the lymphatic system of the eye includes the hyaloid canal, the perichorioidal space, and the space of Tenon.

The blood-vessels of the optic nerve supply the lymph to the hyaloid canal, the vessels of the chorioid to the perichorioidal space, and the vessels supplying the optic nerve and capsule of Tenon to Tenon's space.

The outflow of lymph from all the above-mentioned spaces is through the lymph passages which spread out along the optic nerve.

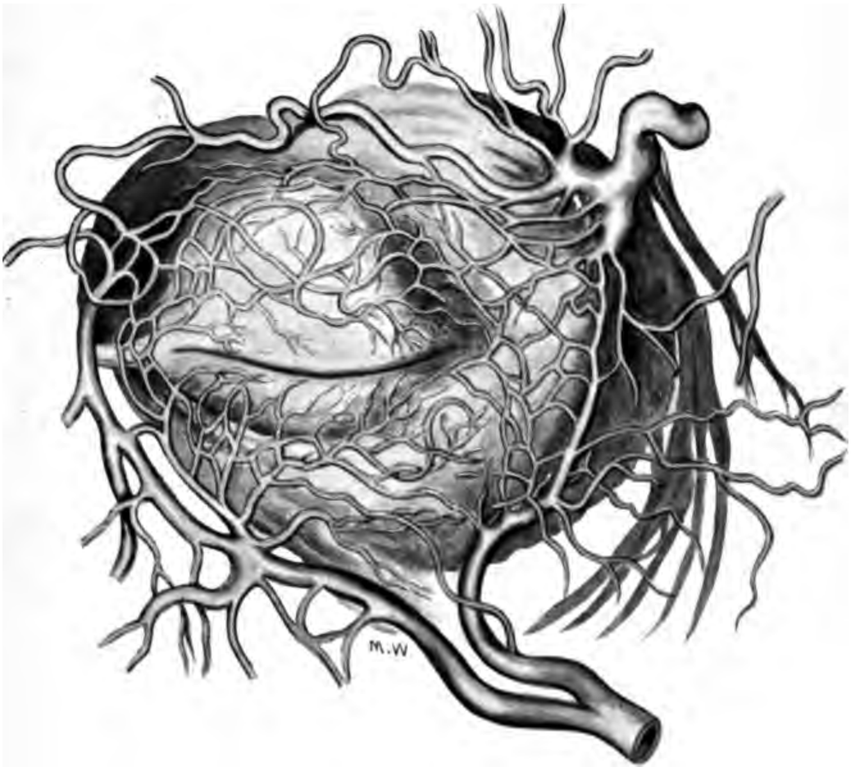

FIG. 14.—VEINS OF THE EYELID.

Nerves of the Eye.—The nerves of the eye and its appendages are the nerve of the special sense of sight—the optic or second cranial; motor nerves from the third, fourth, and sixth; filaments of common sensation from the ophthalmic division of the trifacial or fifth cranial; and filaments from the sympathetic.

The *optic nerve,* the most important nerve of the eye, arises from the optic commissure, passing slightly upward, forward, and outward through the optic foramen into the orbital cavity of each eye. It is formed at the commissure by the decussation of the fibres of the optic tracts.

For convenience of study the optic nerve may be divided as follows:

1. Optic tracts.
2. Optic commissure.
3. Optic nerve.

Each optic tract has a deep and a superficial origin. Its deep origin is from beneath the internal geniculate body; its superficial origin is from the external geniculate body, optic thalamus, and superior corpus quadrigeminus.

From the deep origin of the optic tract fibres pass to the cuneus, the cortical area of vision, while others pass to the nuclei of the motor nerves of the eyeball. Further, some fibres are seen to pass directly to the cuneus from the optic tract and do not undergo interruption in the nucleus where the tract has its origin.

After the formation of the optic tract, it passes forward along the posterior inferior surface of the optic thalamus, crosses the crus, is connected with the tuber cinereum, and lamina cinerea, and in front of the infundibulum unites with the optic tract of the opposite side, thus forming the optic commissure or chiasm, which rests on the optic groove upon the superior surface of the sphenoid bone.

The optic commissure is made up of three groups of fibres, as follows:

Decussating, longitudinal, and intercerebral fibres.

The decussating fibres, which are the most numerous, form the central portion of the optic tract and are continued into the optic nerve of the opposite side, where they decussate with similar fibres of the opposite tract.

The longitudinal fibres form the outer margin of the optic tract and are continued into the optic nerve of the same side.

The intercerebral fibres form the inner or posterior margin of the optic tract and run from one side of the brain to the other.

The optic tract, after it has passed behind the crus cerebri, is divided into an internal and an external portion, by a well-marked groove. The true optic fibres are in the external portion, having their origin as above mentioned. The internal portion is associated with the posterior corpus quadrigeminus and the internal geniculate body, the fibres being continued through the commissure passing from the optic tract of one side to the optic tract of the opposite side. These fibres are not concerned in vision, and constitute the commissures of Meynert and of Gudden.

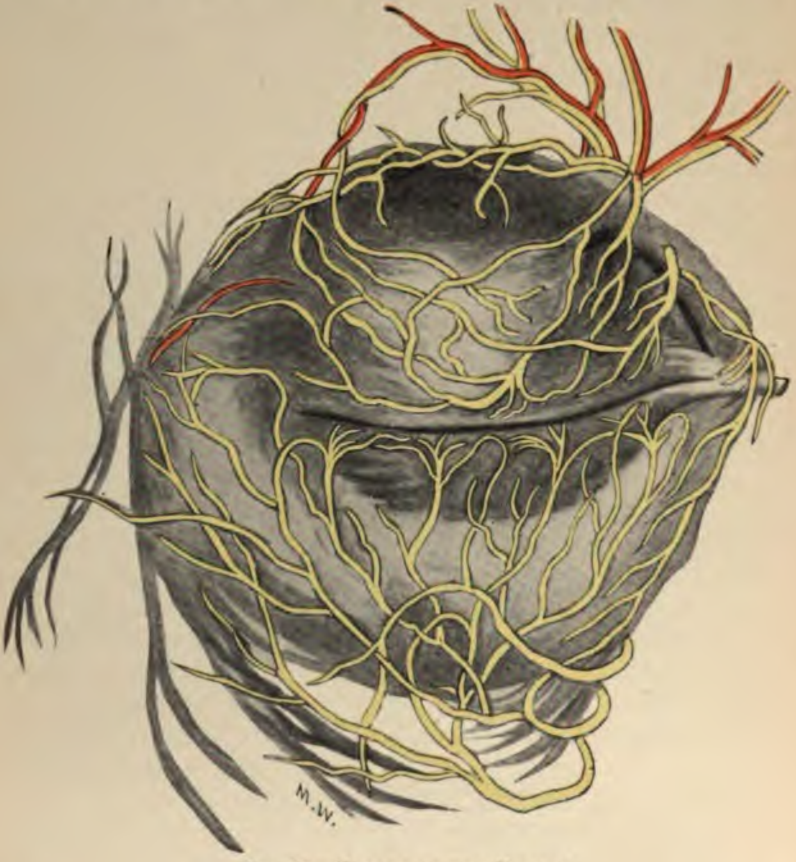

FIG. 15.—NERVES OF THE EYELID.

Each optic nerve, from its origin in the optic commissure, passes forward slightly upward and outward to the optic foramen of its own side. The optic nerve may be divided into three parts, from without inward, as follows:

1. Intra-ocular portion, which is found within the sclerotic coat and is the termination of the optic nerve proper.

2. Orbital portion, which extends between the optic foramen and the globe.

3. Intracranial portion, or that portion extending between the optic foramen and the chiasm. This portion is inclosed in a sheath formed by the arachnoid. At the optic foramen the nerve becomes invested with an additional sheath, derived from the dura mater, which covers the portion of the nerve within the foramen. This latter covering subdivides into two layers as the nerve enters the orbit, one layer becoming continuous with the periosteum of the orbital cavity, and the other layer, together with the arachnoid, surrounding the optic nerve as far as the sclerotic. At the point where the optic nerve enters the globe it becomes constricted in its diameter, at the same time losing its sheath, which becomes continuous with the sclerotic.

The fibres of the optic nerve pass through the sclerotic and chorioidal foramina a little to the nasal side of the axis of the eye. They curve boldly round the margin of the latter foramen, and, spreading in all directions, form the anterior layer of the retina.

The arteria centralis retinæ enters the optic nerve just before the latter penetrates the eyeball, and is continued in a canal of fine fibrous connective tissue to the inner surface of the retina which it supplies. Venules accompany the artery from the eyeball.

The optic nerve is about 1¼ inch (5 centimetres) in length and ⅙ of an inch in diameter at its widest portion. Its function is to convey impressions of sight to the brain. It contains 500,000 to 1,000,000 fibres, each insolated by its medullary sheath.

Appendages of the Eye.—The appendages of the eye, or the *tutamina oculi*, include the following:

The eyebrows (supercilia).

The eyelids (palpebræ).

Conjunctiva.

Lacrymal apparatus: gland, ducts (7 to 10 in number), sac, and nasal duct.

The *eyebrows* are elevated arches of skin surmounting the upper margins of the orbits, covered with short, thick hairs.

The *eyelids* are two movable folds of tissue, covering and protecting the front of the eye. The upper lid is larger, longer, and more movable, being supplied with a special muscle, the *levator palpebræ superioris.*

The lids when opened are separated by an elliptical fissure (*fissura palpebrarum*) each angle of which is termed the outer and inner canthus, respectively.

The inner canthus is prolonged towards the nose for a short distance, and the lids in this position are separated by a triangular space, the *lacus lacrimalis,* at the outer angles of which are the *lacrimal papillæ.* The apex of each papilla is pierced by the *punctum lacrimalis,* the beginning of the lacrymal canal. The lacus lacrimalis is filled by the *caruncula lacrimalis,* a mass of follicles resembling the Meibomian glands, and covered by the conjunctiva.

The structure of the eyelids from without inward is as follows:

Skin.
Subcutaneous areolar tissue.
Fibres of the orbicularis muscle.
Tarsal plates.
Fibrous membrane (tarsal ligament).
Meibomian glands.
Vessels and nerves.
Conjunctiva.

The skin is thin, being attached by a very loose areolar tissue to the muscle beneath.

The fibres of the orbicularis palpebrarum are pale, thin, and act involuntarily as well as voluntarily.

The tarsal plates—two in number—are composed of dense connective tissue; the superior, the larger, is semilunar in shape, the inferior is elliptical. The inner margins are fixed to the orbit by the *tendo oculi.*

The fibrous membrane of the lids, or tarsal ligament, passes over the anterior surface of the tarsal plate, being attached to the free margin of the latter below and to the malar bone externally.

The Meibomian glands in the upper lid number about thirty; they are somewhat fewer in the lower lid. They are arranged vertically on the inner surface of the cartilages, and are straight sebaceous glands into which a number of secondary follicles open. They terminate above in an extremity, opening below, on the free margin of the lids, by small foramina corresponding to the number of tubules.

The eyelashes, or cilia, are arranged on the free border of the lids in two or three rows.

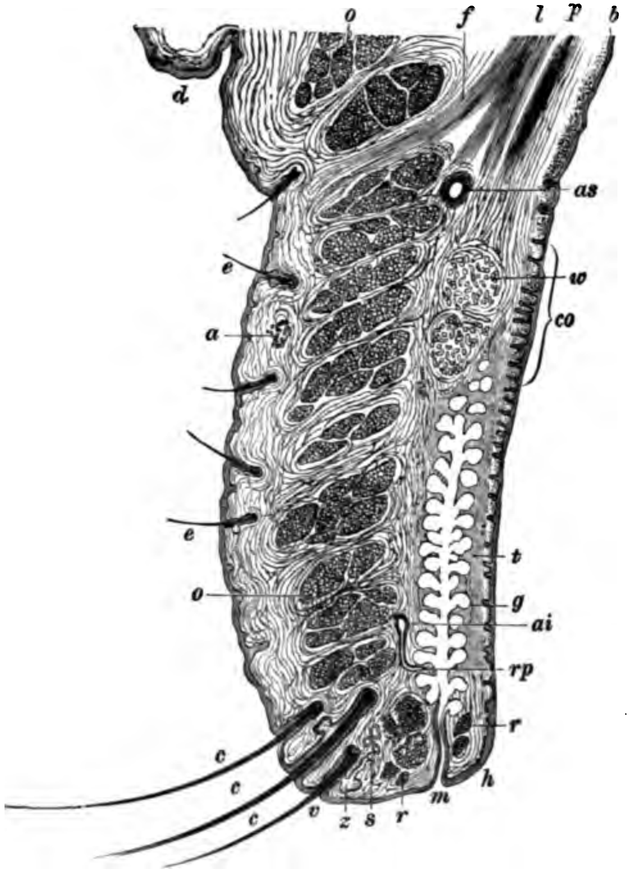

FIG. 16.—PERPENDICULAR SECTION THROUGH THE UPPER LID. Magnified 5 × 1.

The skin of the lid presents in the upper part, above a sulcus, the protecting fold, *d*; below, it covers the anterior edge of the lid, *v*. In the skin are found fine hairs, *e*, *e*, sweat glands, *a*, cilia, *c*, *c*, *c*, and in the neighbourhood of the latter Zeiss's glands, *z*, and the modified sweat glands, *s*. Beneath the skin lie the transversely divided bundles of fibres of the orbicularis, *o*, *o*, of which those placed most internally, *r*, *r*, form the musculus ciliaris Riolani. The posterior surface of the lid is covered by conjunctiva which is intimately adherent to the tarsus, *t*, and over the latter shows isolated papillæ, especially at *co*, over the convex border of the tarsus. Still higher up, at *b*, in the vicinity of the fornix, the conjunctiva shows an adenoid character. The Meibomian glands, *g*, have their orifices, *m*, in front of the posterior edge, *h*, of the lid; above them lie Waldeyer's mucous glands, *w*, and still higher Müller's musculus palpebralis superior, *p*, and the levator palpebræ superioris, *l*. From the latter the leash of fibres, *l*, passes to the skin of the lid. *as* is the arcus tarseus superior *ai*, the arcus tarseus inferior; from the latter the rami perforantes, *rp*, run, at first straight downward, then backward, through the tarsus.

The conjunctiva, the mucous membrane lining the eyelids, is reflected over the cornea and anterior portion of the sclerotic. It consists of two portions: the ocular portion, which is reflected over the sclerotic and cornea, and the palpebral portion, which lines the internal surface of the lids.

The ocular portion is loosely connected with the sclerotic, but over the cornea it becomes firmly adherent. In the latter position it is structureless, consisting only of the epithelial layer.

The palpebral portion is thick, highly vascular, and contains many papillæ. At the inner angle of the eye it forms a semilunar fold, the *plica semilunaris*—the rudiment of the nictitating membrane of birds, the *membrana nictitans.*

The point of reflection from the eyelids to the eyeball is called the *fornix conjunctivæ,* and the reflected portions the *superior* and *inferior palpebral folds.*

The lacrymal apparatus consists of the lacrymal gland and its ducts, the lacrymal sac, and nasal duct.

The lacrymal gland is an oval, glandular body, about the shape and size of an almond, situated in a depression at the upper outer angle of the orbit, on the inner side of the external angular process of the frontal bone.

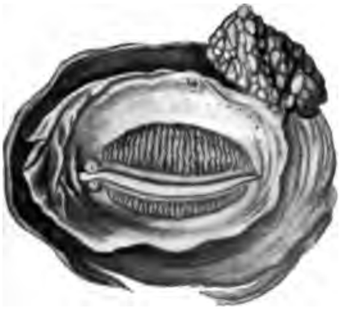

FIG. 17.—LACHRYMAL GLAND AND MEIBOMIAN GLANDS.

The anterior portion of the gland is sometimes described as a separate lobe—the *palpebral portion of the gland* or *accessory gland of Rosenmüller.*

The gland is attached to the bony roof of the orbit by the tarso-orbital fascia.

The ducts, 7 to 10 in number, open by minute orifices arranged in a row upon the conjunctiva near its point of reflection.

The lacrymal canals commence at the puncta lacrimalis, at the summits of the papillæ lacrimalis, and empty by two canaliculi into the lacrymal sac.

The superior canal at first ascends and then descends obliquely inward and downward, while the inferior descends at first and then passes nearly horizontally inward.

The lacrymal sac is the oval, dilated, upper portion of the nasal duct lodged in a deep groove formed by the nasal process of the superior maxilla and the lacrymal bone. It is crossed by the *tensor tarsi* muscle (sometimes called Horner's muscle), which acts as a compressor, and receives a fibrous expansion from the tendo oculi.

It is made up of a fibro-elastic coat, lined by mucous membrane continuous with that of the nose and conjunctiva.

The nasal duct is a membranous tube about three-quarters of an inch in length, extending from the lacrymal sac to the inferior meatus of the nose, and lining the bony lacrymo-nasal canal. It passes backward, downward, and outward, and is protected at its inferior extremity by a valve composed of mucous membrane—the valve of Hasner.

The mucous lining is continuous with that of the sac, but instead of having squamous epithelium it is ciliated in the duct.

cludes the hyaloid canal, the perichorioidal space, and the space of Tenon.

The blood-vessels of the optic nerve supply the lymph to the hyaloid canal, the vessels of the chorioid to the perichorioidal space, and the vessels supplying the optic nerve and capsule of Tenon to Tenon's space.

The outflow of lymph from all the above-mentioned spaces is through the lymph passages which spread out along the optic nerve.

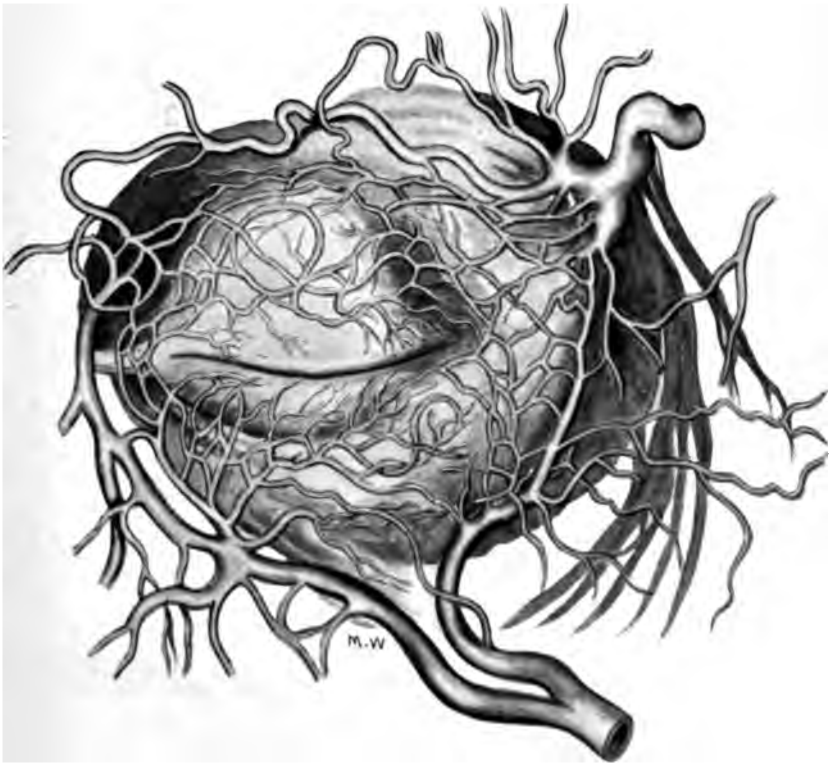

FIG. 14.—VEINS OF THE EYELID.

Nerves of the Eye.—The nerves of the eye and its appendages are the nerve of the special sense of sight—the optic or second cranial; motor nerves from the third, fourth, and sixth; filaments of common sensation from the ophthalmic division of the trifacial or fifth cranial; and filaments from the sympathetic.

The *optic nerve,* the most important nerve of the eye, arises from the optic commissure, passing slightly upward, forward, and outward through the optic foramen into the orbital cavity of each eye. It is formed at the commissure by the decussation of the fibres of the optic tracts.

For convenience of study the optic nerve may be divided as follows:

1. Optic tracts.
2. Optic commissure.
3. Optic nerve.

Each optic tract has a deep and a superficial origin. Its deep origin is from beneath the internal geniculate body; its superficial origin is from the external geniculate body, optic thalamus, and superior corpus quadrigeminus.

From the deep origin of the optic tract fibres pass to the cuneus, the cortical area of vision, while others pass to the nuclei of the motor nerves of the eyeball. Further, some fibres are seen to pass directly to the cuneus from the optic tract and do not undergo interruption in the nucleus where the tract has its origin.

After the formation of the optic tract, it passes forward along the posterior inferior surface of the optic thalamus, crosses the crus, is connected with the tuber cinereum, and lamina cinerea, and in front of the infundibulum unites with the optic tract of the opposite side, thus forming the optic commissure or chiasm, which rests on the optic groove upon the superior surface of the sphenoid bone.

The optic commissure is made up of three groups of fibres, as follows:

Decussating, longitudinal, and intercerebral fibres.

The decussating fibres, which are the most numerous, form the central portion of the optic tract and are continued into the optic nerve of the opposite side, where they decussate with similar fibres of the opposite tract.

The longitudinal fibres form the outer margin of the optic tract and are continued into the optic nerve of the same side.

The intercerebral fibres form the inner or posterior margin of the optic tract and run from one side of the brain to the other.

The optic tract, after it has passed behind the crus cerebri, is divided into an internal and an external portion, by a well-marked groove. The true optic fibres are in the external portion, having their origin as above mentioned. The internal portion is associated with the posterior corpus quadrigeminus and the internal geniculate body, the fibres being continued through the commissure passing from the optic tract of one side to the optic tract of the opposite side. These fibres are not concerned in vision, and constitute the commissures of Meynert and of Gudden.

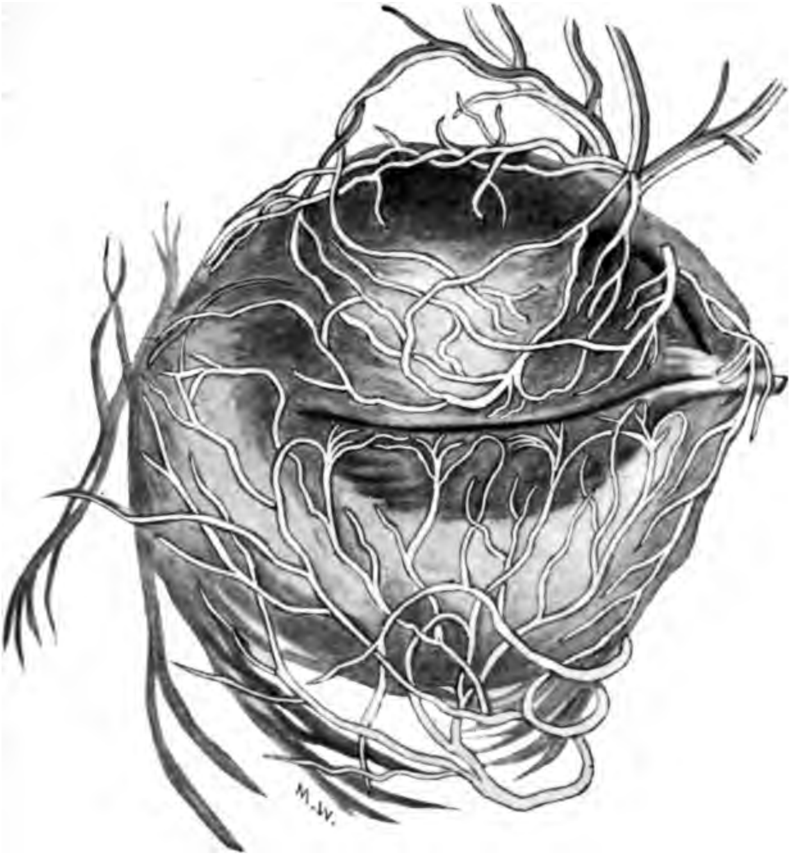

FIG. 15.—NERVES OF THE EYELID.

Each optic nerve, from its origin in the optic commissure, passes forward slightly upward and outward to the optic foramen of its own side. The optic nerve may be divided into three parts, from without inward, as follows:

1. Intra-ocular portion, which is found within the sclerotic coat and is the termination of the optic nerve proper.

2. Orbital portion, which extends between the optic foramen and the globe.

3. Intracranial portion, or that portion extending between the optic foramen and the chiasm. This portion is inclosed in a sheath formed by the arachnoid. At the optic foramen the nerve becomes invested with an additional sheath, derived from the dura mater, which covers the portion of the nerve within the foramen. This latter covering subdivides into two layers as the nerve enters the orbit, one layer becoming continuous with the periosteum of the orbital cavity, and the other layer, together with the arachnoid, surrounding the optic nerve as far as the sclerotic. At the point where the optic nerve enters the globe it becomes constricted in its diameter, at the same time losing its sheath, which becomes continuous with the sclerotic.

The fibres of the optic nerve pass through the sclerotic and chorioidal foramina a little to the nasal side of the axis of the eye. They curve boldly round the margin of the latter foramen, and, spreading in all directions, form the anterior layer of the retina.

The arteria centralis retinæ enters the optic nerve just before the latter penetrates the eyeball, and is continued in a canal of fine fibrous connective tissue to the inner surface of the retina which it supplies. Venules accompany the artery from the eyeball.

The optic nerve is about 1¼ inch (5 centimetres) in length and $\frac{1}{6}$ of an inch in diameter at its widest portion. Its function is to convey impressions of sight to the brain. It contains 500,000 to 1,000,000 fibres, each insolated by its medullary sheath.

Appendages of the Eye.—The appendages of the eye, or the *tutamina oculi*, include the following:

The eyebrows (supercilia).

The eyelids (palpebræ).

Conjunctiva.

Lacrymal apparatus: gland, ducts (7 to 10 in number), sac, and nasal duct.

The *eyebrows* are elevated arches of skin surmounting the upper margins of the orbits, covered with short, thick hairs.

The *eyelids* are two movable folds of tissue, covering and protecting the front of the eye. The upper lid is larger, longer, and more movable, being supplied with a special muscle, the *levator palpebræ superioris.*

The lids when opened are separated by an elliptical fissure (*fissura palpebrarum*) each angle of which is termed the outer and inner canthus, respectively.

The inner canthus is prolonged towards the nose for a short distance, and the lids in this position are separated by a triangular space, the *lacus lacrimalis,* at the outer angles of which are the *lacrimal papillæ.* The apex of each papilla is pierced by the *punctum lacrimalis,* the beginning of the lacrymal canal. The lacus lacrimalis is filled by the *caruncula lacrimalis,* a mass of follicles resembling the Meibomian glands, and covered by the conjunctiva.

The structure of the eyelids from without inward is as follows:

Skin.
Subcutaneous areolar tissue.
Fibres of the orbicularis muscle.
Tarsal plates.
Fibrous membrane (tarsal ligament).
Meibomian glands.
Vessels and nerves.
Conjunctiva.

The skin is thin, being attached by a very loose areolar tissue to the muscle beneath.

The fibres of the orbicularis palpebrarum are pale, thin, and act involuntarily as well as voluntarily.

The tarsal plates—two in number—are composed of dense connective tissue; the superior, the larger, is semilunar in shape, the inferior is elliptical. The inner margins are fixed to the orbit by the *tendo oculi.*

The fibrous membrane of the lids, or tarsal ligament, passes over the anterior surface of the tarsal plate, being attached to the free margin of the latter below and to the malar bone externally.

The Meibomian glands in the upper lid number about thirty; they are somewhat fewer in the lower lid. They are arranged vertically on the inner surface of the cartilages, and are straight sebaceous glands into which a number of secondary follicles open. They terminate above in an extremity, opening below, on the free margin of the lids, by small foramina corresponding to the number of tubules.

The eyelashes, or cilia, are arranged on the free border of the lids in two or three rows.

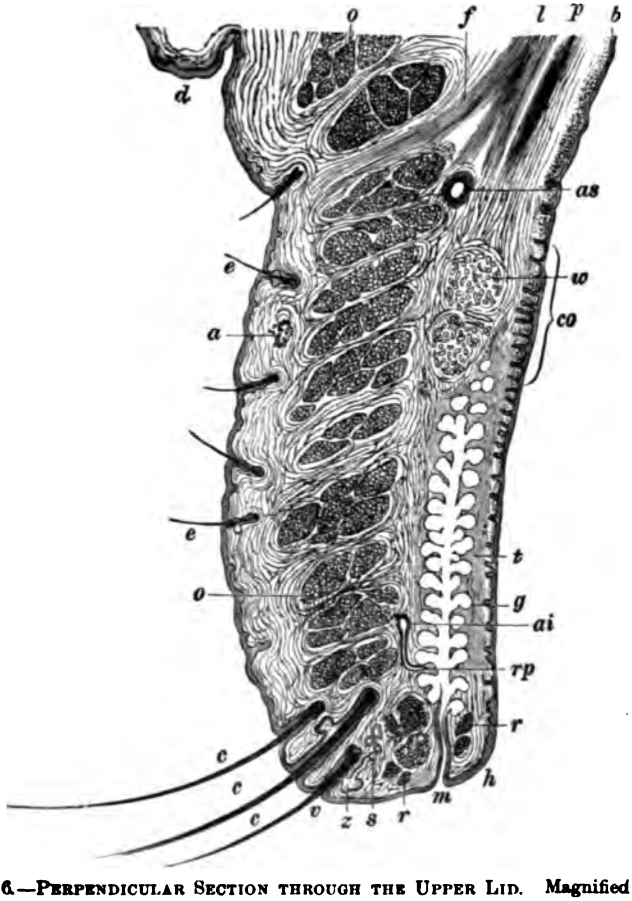

Fig. 16.—Perpendicular Section through the Upper Lid. Magnified 5 × 1.

The skin of the lid presents in the upper part, above a sulcus, the protecting fold, *d*; below, it covers the anterior edge of the lid, *v*. In the skin are found fine hairs, *e*, *e*, sweat glands, *a*, cilia, *c*, *c*, *c*, and in the neighbourhood of the latter Zeiss's glands, *z*, and the modified sweat glands, *s*. Beneath the skin lie the transversely divided bundles of fibres of the orbicularis, *o*, *o*, of which those placed most internally, *r*, *r*, form the musculus ciliaris Riolani. The posterior surface of the lid is covered by conjunctiva which is intimately adherent to the tarsus, *t*, and over the latter shows isolated papillæ, especially at *co*, over the convex border of the tarsus. Still higher up, at *b*, in the vicinity of the fornix, the conjunctiva shows an adenoid character. The Meibomian glands, *g*, have their orifices, *m*, in front of the posterior edge, *h*, of the lid; above them lie Waldeyer's mucous glands, *w*, and still higher Müller's musculus palpebralis superior, *p*, and the levator palpebræ superioris, *l*. From the latter the leash of fibres, *l*, passes to the skin of the lid. *as* is the arcus tarseus superior *ai*, the arcus tarseus inferior; from the latter the rami perforantes, *rp*, run, at first straight downward, then backward, through the tarsus.

nasal duct lodged in a deep groove formed by the nasal process of the superior maxilla and the lacrymal bone. It is crossed by the *tensor tarsi* muscle (sometimes called Horner's muscle), which acts as a compressor, and receives a fibrous expansion from the tendo oculi.

It is made up of a fibro-elastic coat, lined by mucous membrane continuous with that of the nose and conjunctiva.

The nasal duct is a membranous tube about three-quarters of an inch in length, extending from the lacrymal sac to the inferior meatus of the nose, and lining the bony lacrymo-nasal canal. It passes backward, downward, and outward, and is protected at its inferior extremity by a valve composed of mucous membrane—the valve of Hasner.

The mucous lining is continuous with that of the sac, but instead of having squamous epithelium it is ciliated in the duct.

CHAPTER III

DISEASES OF THE EYELIDS

THE most rational division of the affections that involve the eyelids is that in which the abnormal conditions are grouped according to the structures attacked. From without inward the lids are composed of skin, loose areolar tissue, cilia, tarsal cartilage, muscle fibres, fibrous membrane, Meibomian glands and conjunctiva, each of which is subject to various diseases that differ greatly in their clinical appearance.

The skin of the lids is subject to congestion, inflammation, hypertrophies, disorders of the glands, injuries, morbid growths, etc.

The infectious fevers that are attended by eruptions upon the body surface are sometimes manifested upon the eyelids as elsewhere. Similarly urticaria and diseases of the same class may have lesions in this situation. It must be remembered that they occur independent of any ocular condition. In small-pox extension of the lesion may induce serious changes in the eye.

Inflammation of the integument of the lids, or dermatitis, usually arises from contact with poison ivy or poison oak, constituting *dermatitis venenata.* The swelling and œdema is so great that it is impossible to open the eyelids, the skin of which is covered by innumerable vesicles and bullæ. The itching is intense. In all such cases the application of a saturated solution of boric acid (15 grains to the ounce) with glycerin (10 minims to the ounce) or a 1 to 2,000 chinosol solution will afford considerable relief. The inflammation terminates favourably in a few days.

Ulceration of the eyelids is usually due to some condition, such as syphilis or epithelioma, but occasionally is seen as an independent affection. The case shown in the accompanying illustration is one of infectious ulceration, and is unusually intense in character. The condition followed contact with the discharge from chancroids and condylomata in the female genital region, the infective material being carried to the eyelids by the finger. Ulceration of the eyelid followed within four days after inoculation

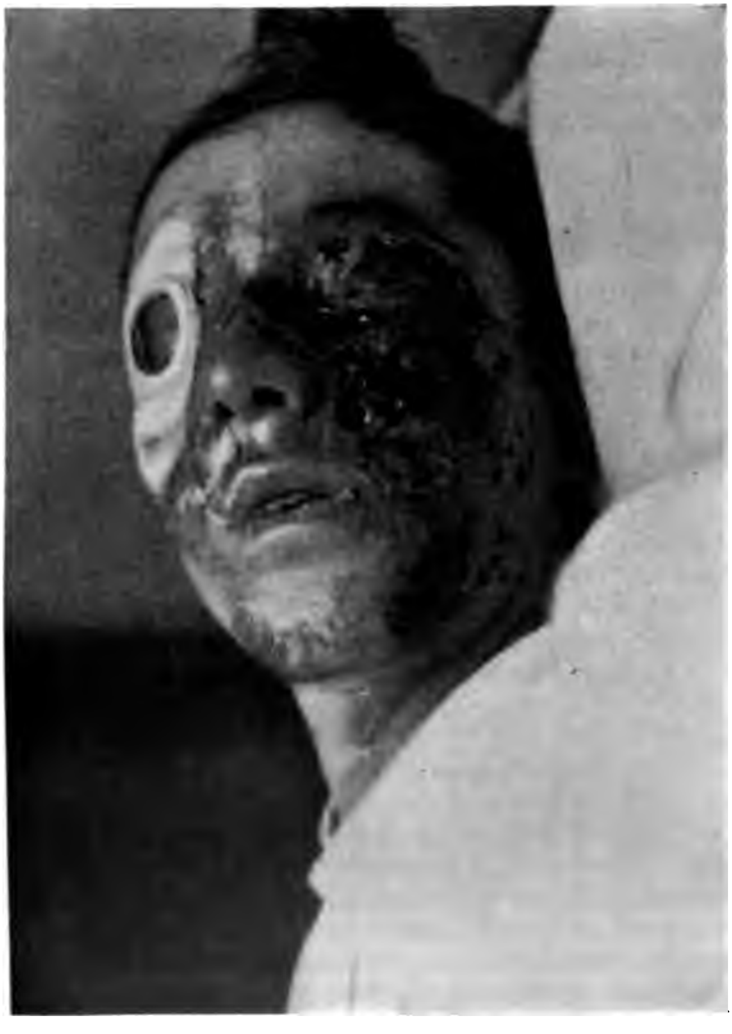

FIG. 18.—INFECTIOUS ULCERATION OF EYELID. TWELFTH DAY.

and extension to the other ocular structures induced purulent conjunctivitis and corneal ulceration. The discharge was profuse and produced secondary ulceration of all portions of the face with which it came in contact. The photograph was taken upon the twelfth day of the affection, when the left side of the face was one sloughing area. The treatment consisted in protecting the unaffected eye by means of a Buller's shield, after which the ulcerated lesions were thoroughly scraped and cauterized with a 50-per-cent solution of trichloracetic acid. Antiseptic lotions were used at

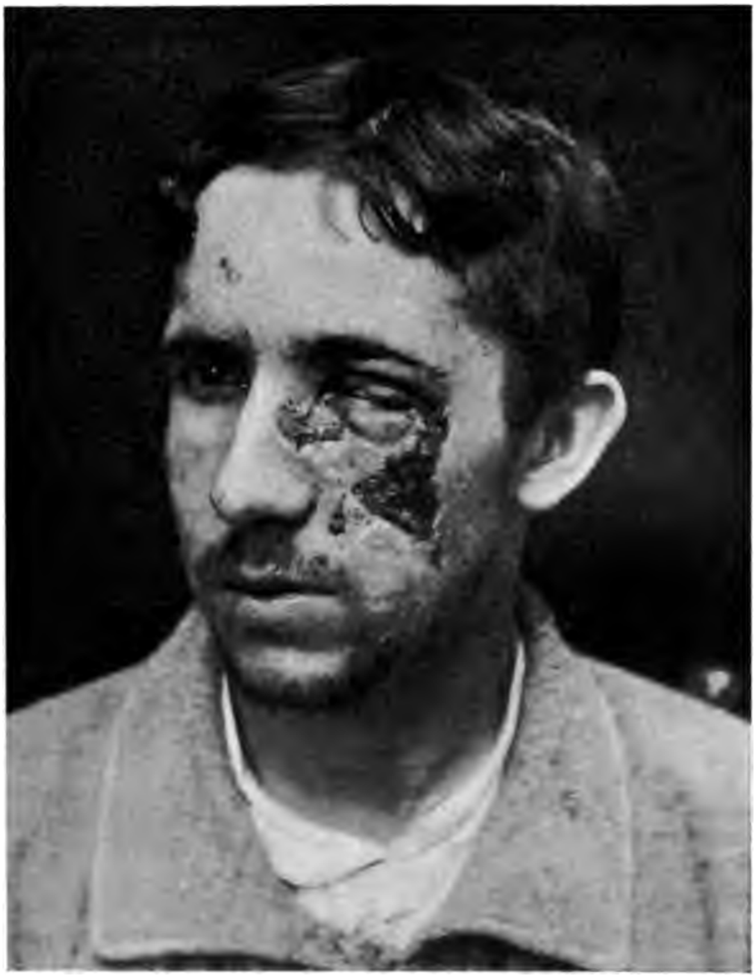

FIG. 19.—INFECTIOUS ULCERATION OF EYELID. THIRD WEEK.

frequent intervals to destroy the infection. Three weeks later the second photograph was taken, showing that the course of the affection was very short. The skin of the face and eyelid returned to normal with but very slight scarring, but the cornea became very opaque, rendering the eye useless as a visual organ.

Abscess of the eyelids most frequently follows some traumatism to the eye or adjoining structures.

All the symptoms of inflammation and suppuration are present. Hot antiseptic applications should be employed to hasten pointing if seen early, and an incision should be made parallel to the muscle fibres as soon as fluctuation is detected.

Furunculosis consists in a local infection of one or more of the hair follicles by staphylococci, and is much benefited by the application of ichthyol ointment (1 dram to the ounce). Incision may be made as soon as suppuration has occurred.

Erysipelas may affect the eyelids as a part of the general erysipelas of the face, and is characterized by heat, pain, redness, vesication, and a sharply defined edge which is elevated above the surrounding skin. It is attended by swelling and œdema, which may render opening of the lids impossible. Chilliness, malaise, headache, anorexia, and fever (102° to 105° F.) are nearly always present. The affection seldom lasts more than four or five days, and tends to recur. Its presence contra-indicates any operation upon the eyes or eyelids.

The treatment consists largely in the internal administration of pilocarpine, quinine, tincture of the chloride of iron, strychnine, and the stimulants to maintain the resistance of the system. Locally, weak solutions of nitrate of silver, 1-to-2,000 chinosol, a saturated solution of boric acid, or carbolized petrolatum may be employed.

Eczema of the eyelids is a very common affection, and is usually erythematous in character, although the other varieties of the disease may occur. It is most frequent in those past middle life and in individuals who are exposed to high degrees of heat and cold. Irritants of various kinds are responsible for it. The disease is worse in winter and chronic in nature, showing a marked tendency to relapse. It begins as bright or dull red spots, the margins of which are ill defined, to be followed by coalescence of the spots with the production of a diffusely reddened area. The intensity of the inflammation may induce œdema of the loose areolar tissue, causing closure of the eyelids. In this respect it resembles erysipelas, but the absence of constitutional disturbances and the other symptoms will serve to distinguish it. The itching is intense and is aggravated by scratching.

The treatment consists in the withdrawal of all irritants, and the use of soap and water in this situation should be especially interdicted. Sedative lotions, such as the following, are of great value:

℞ Acid. boric.	gr. xlv;
Glycerin	♏xxx;
Aq. camphor.	℥iij.
M.	

Sig.: Apply locally three or four times daily.

℞ Resorcin	gr. xx;
Glycerin	♏xxx;
Liquor calcis	℥iij.
M.	

Sig.: Apply locally three times daily.

The ointments of boroglyceride and yellow oxide of mercury (gr. ½ to the dram) are also beneficial in some cases.

Blepharitis (sycosis, tarsi, blepharo-adenitis, blepharitis ciliaris), or inflammation of the margin of the lids, is the most common affection to which those structures are liable. It arises from a number of causes, the most frequent being uncorrected ametropia. Less common factors in its production are inflammatory conditions of adjacent structures, such as eczema of the lids and face, conjunctivitis, keratitis, inflammation or degeneration of the roots of the eyelashes, lice, uncleanliness, and constitutional disturbances, such as attend tuberculosis and syphilis.

Two varieties of blepharitis are recognised: squamous and ulcerative.

Squamous blepharitis is the milder form, and is characterized by redness and scaliness of the lid margins, attended by intense itching and burning, aggravated by prolonged use of the eyes and exposure to bright light for any length of time. During sleep the inflammatory exudate accumulates so that on awakening the lids are found glued together by yellowish gummed secretion.

frequent intervals to destroy the infection. Three weeks later the second photograph was taken, showing that the course of the affection was very short. The skin of the face and eyelid returned to normal with but very slight scarring, but the cornea became very opaque, rendering the eye useless as a visual organ.

Abscess of the eyelids most frequently follows some traumatism to the eye or adjoining structures.

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The treatment consists largely in the internal administration of pilocarpine, quinine, tincture of the chloride of iron, strychnine, and the stimulants to maintain the resistance of the system. Locally, weak solutions of nitrate of silver, 1-to-2,000 chinosol, a saturated solution of boric acid, or carbolized petrolatum may be employed.

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Ecchymosis is the technical name for the extravasation of the blood that takes place into the skin as the result of traumatism, and is a common occurrence in connection with the eyelids. In this situation it constitutes *black eye,* and gives rise to a play of colours beginning with red and gradually becoming darker, due to the disintegration of the blood and its pigment. Hæmorrhage into the lower areolar tissue may occur from injury, or it may be a part of a general systemic disturbance, such as scurvy, purpura, etc.

The treatment varies according to the stage of the condition. Owing to the disfigurement it occasions, every means should be taken to prevent the outflow of blood into the tissues. Towards this end, cold applications, preferably ice compresses of gauze, are recommended, and should be applied for ten minutes every two hours for the first twelve hours. If the blood has already been poured out, hot compresses, sedative lotions—liq. ammon. acetas alone or mixed with rose water (equal parts), or a poultice of the root of black bryony and bread crumbs (Tyrrell)—should be used. A pressure bandage should be employed to aid in its absorption.

The formulas below have been found most beneficial in bruised eyelids:

℞ Ammon. hydrochlorat. .... ℥i;
Alcoholis destil. .... ℥ij;
Aq. rosæ dil. .... ℥iv.
M.

Sig.: Apply freely to the bruised eyelids.

℞ Ichthyol ammon. .... ʒi to ʒiij;
Aq. destil. .... ℥iv.
M.

Sig.: Apply cold.

In the early stage, when there is a collection of blood in the loose areolar tissue space, it is a common practice in certain social circles to apply a leech to withdraw the blood. The cosmetic effect may be greatly improved by the use of calamine ointment (youthful tint paste) toned down with powder.

Œdema of the eyelids is nearly always bilateral, and is due to some disease of the heart, liver, or kidneys, but may be unilateral as the result of inflammatory or traumatic conditions. Œdema upon arising in the morning is often one of the first symptoms of real dropsy. Angioneurotic œdema due to the administration of drugs and disturbances of the nervous system may also occur in this situation, and is usually unilateral.

The treatment should be directed towards the underlying condition, but occasionally the tension upon the skin is so great as to require " puncturing with the antiphlogistic touch of the therapeutic knife " (Pancoast). The following lotion has proved most beneficial in cases of œdema:

℞ Acidi borici	ʒi;
Vini gallici, Alcoholis,	āā ℥ii.
M. S.: Use locally.	

Psoriasis is a very rare condition of the skin of the eyelids characterized by hyperæmic patches covered by imbricated mother-of-pearl scales. The removal of the scales reveals a superficial inflammation of the skin. Psoriasis of the face is always an accompaniment. Stimulating ointments are advisable, and internal medication is necessary. In this situation the disease is obstinate, and should not be mistaken for affections of the lids due to eye-strain.

Emphysema consists in the distention of the lid by air, and is usually due to fracture to the bones of the nose or the production of a false passage in probing the nasal duct. It is most manifest upon blowing the nose, inducing sudden swelling and distention, that subsides shortly afterward.

Seborrhœa, a functional disease of the sebaceous glands, sometimes involves the eyelids as a part of a seborrhœa of the head and face. It has no connection with blepharitis. It is characterized by scaliness or oily secretion. A weak sulphur ointment (30 grains to the ounce of petrolatum) is very beneficial in this condition.

Milium is another disease of the sebaceous glands that attacks the eyelids. It is characterized by small yellow or pearly white round bodies beneath the epidermis. They are translucent and slightly elevated above the skin. Calcareous degeneration may occur, resulting in cutaneous calculi. The cause is unknown. Removal is indicated, and it may be accomplished by puncturing and touching the exposed sac with nitrate of silver, electrolysis, or pressure. Large accumulation of sebaceous matter in the glands constitute sebaceous cysts or wens.

Herpes zoster ophthalmicus is an unusual affection of the lids, and possesses the characteristics of herpes zoster elsewhere in the body. The condition is acutely inflammatory, and is manifested by the formation of tense vesicles grouped together along the course of the supraorbital nerve and accompanied by excruciating neuralgic pains, particularly before the appearance of the eruption. The vesicles show no tendency to spontaneous rupture, and involve but one side of the face at a time. They dry in one or two weeks, and fall off, not infrequently leaving scars. In rare cases the blisters may become pustular, hæmorrhagic, or gangrenous. Involvement of the cornea and iris may occur, resulting in their destruction. The disease is due to some neurotic disturbance.

The treatment is directed largely towards the relief of the pain. Phenacetin and other coal-tar derivatives may be administered, but frequently morphine is necessary. Locally, flexible collodion, containing 10 grains of morphine to the ounce, may be employed, or dusting powders of zinc oxide, starch, talc, etc., may be used. The galvanic current is also of value.

Hyperidrosis, or excessive sweating, may occur upon the eyelids as the result of some neurotic disturbance. It is a functional condition due to abnormal activity of the sweat glands, and is most marked in unilateral sweating.

Chromidrosis of the palpebral region is another disorder of the sweat glands characterized by patches of pigmentation on the skin, especially of the lower lid. It is most frequent in females, and may be removed by oil or glycerin, but promptly returns. It is more or less periodic in character, and its cause is unknown. The affection is simulated sometimes by hysterical individuals.

Hydrocystadenoma is a still rarer affection of the sweat glands, and is also seen upon the eyelids. It is non-inflammatory, and is characterized by translucent, deep-seated, persistent vesicles resembling sudamina.

NEW GROWTHS UPON THE EYELIDS

Epithelioma, or skin cancer, attacking the eyelids, is usually superficial or of the rodent ulcer type. The superficial variety is characterized by one or more grouped yellowish papules or patches of degenerative seborrhœa. It begins after middle life. The lesions become excoriated and scales and crusts form, which are removed only to be followed by other crusts. The course of this form of the disease is very slow, and years may elapse before ulceration takes place. When ulceration is present it is rounded in shape with well-defined pearly or rolled borders. It may be elevated or depressed, and the edges are indurated. Bleeding occurs upon the slightest injury, and a secretion of yellowish fluid is often present. The general health is unimpaired, and there is no lymphatic involvement or metastasis. Destruction of the growth in its early stage is indicated, and may be accomplished by the use of caustics, such as arsenious acid, caustic potash, or pyrogallic acid. Excision may also be performed or skin-grafts applied. These procedures, excepting skin-grafting, leave behind scars that may cause considerable deformity. The application of the X-ray is probably the best form of treatment.

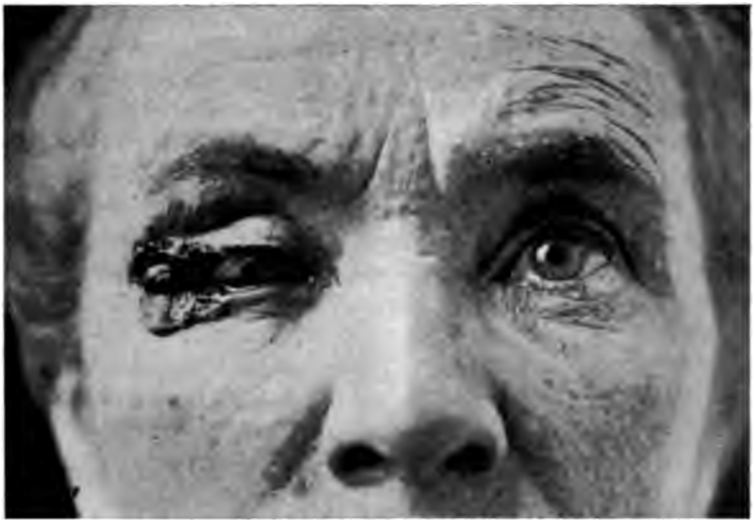

Fig. 21.—Epithelioma of Eyelids.

The *rodent ulcer* (Jacobs's ulcer) form of epithelioma most often attacks the lower lid at its inner half. It begins as a hard papule or nodule that ulcerates early in the course of the disease without the formation of any new tissue. It has a punched-out appearance and a slight roll-like border. The lymphatic glands behind the ear and in the post-cervical region are not involved until late in the affection. The disease usually occurs in the latter part of middle life, and shows a marked tendency to destroy tissue. It is chronic and is attended by very little cachexia.

The treatment is difficult on account of the small amount of tissue that may be removed. Excision of the edges serves to enlarge the ulcer, and there is seldom enough vitality to the skin to regenerate and fill up the excavated area. If seen very early, excision or other methods of removal may be employed. In later cases the X-ray offers the most hope of cure. The author has found good results in skin-grafting.

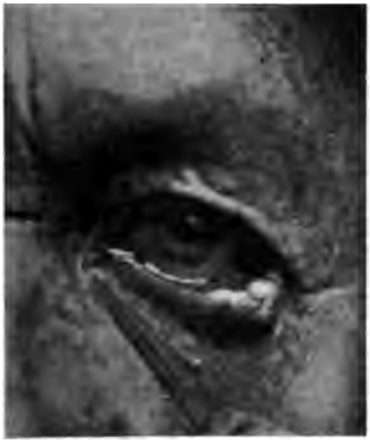

Fig. 22.—Rodent Ulcer of Lower Lid Before Operation.

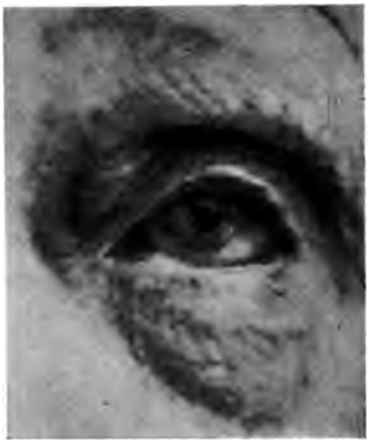

Fig. 23.—Rodent Ulcer of Lower Lid After Skin-grafting.

Syphilis of the eyelid may occur in any stage of the disease. Apart from recognition of the disease for the sake of the patient's general health, it is important to distinguish chancre from beginning cancer or sarcoma on account of the results of treatment upon the eyelids. Chancre in this situation causes enlargement and eversion of the lid, with the characteristic parchment-like induration. It is most often located at the inner angle of the lids.

There is enlargement of the post-cervical lymphatic glands, and the secondary eruptions upon the body may or may not be present. The difficulty in recognising extragenital chancres arises from the fact that the ordinary description given applies only to the genital lesions, and it is obvious that they undergo more or less alteration in the various parts of the body according to the character of the structure in which they are found. The induration and the pseudo-membranous covering, however, are characteristic in all situations. In some cases the chancre appears as a superficial abrasion under which the parchment-like infiltration may be detected.

The macules, papules, and pustules of syphilis may occur on the external surface of the eyelids as elsewhere. Upon the mucous membrane of the lids the papule becomes converted into the mucous patch.

The late lesions of syphilis, tubercles, and gummas, may occasionally form upon the lids. The tubercular form is characterized by brownish-red or ham-coloured, deep-seated papules or tubercles usually arranged in the shape of an incomplete ring. Gummas begin as circumscribed infiltrations of the tissue underlying the skin, which increase in size, forming one or more flat, painless tumours. These break down and ulcerate without any true inflammatory reaction.

The treatment consists in the internal administration of mercury, or iodides, or both. Local treatment is unnecessary.

Lupus erythematosus, or lupus non-exedens, is a new growth involving the skin of the face, but sometimes extends to that of the eyelids. It is characterized by sharply marginated reddish patches covered by yellowish scales firmly adherent to the skin. As it exhausts its soil it leaves behind white atrophic cicatricial areas. The affection occurs most often in women, and is essentially a disease of middle life. It is extremely chronic, and runs an indefinite course.

The treatment is almost entirely external in character, and includes applications of sulphur ointment (1 dram to the ounce), salicylic acid in collodion (10 grains to the ounce), the X-ray, and sometimes scarification.

Lupus vulgaris, or lupus exedens, is the most important disease on account of the pronounced scarring produced by its extension to the eyelids. The disease is a form of dermal tuberculosis and belongs to the class of new growths of the skin. It is characterized by reddish or brownish patches made up of papules, nodules, and flat infiltrations. When the eyelids are involved the disease is usually diffused over the greater portion of the face. The yellowish or brownish flat papules are softer than the adjacent skin, and constitute the "apple-jelly" nodules first described by Mr. Jonathan Hutchinson. The papules develop into nodules, and these by aggregation form patches. After a varying period the lesions undergo retrograde changes, disappearing by absorption or ulceration. Scarring is a sequel in either event. The disease begins in youth and lasts indefinitely.

The treatment is local and general. The local treatment consists largely in curettement and cauterization, but the best results have been obtained by the use of the X-ray and the concentrated-light treatment after the method of Finsen. Internally, tonics and stimulants are of great value.

Nævus, or angioma, or similar vascular tumours are very frequent, and are congenital in origin. The port-wine birth-mark of the face often involves the eyelids, and sometimes the abnormal blood-vessels form a pedunculated tumour. The colour depends upon the predominance of either the venous or arterial vessels being brighter when the arteries are in excess.

The treatment in the sessile growths consists in removal, and this is best accomplished by electrolysis. This is a tedious procedure, and requires great care to avoid pain and subsequent scarring. In the pedunculated tumours excision may also be practised, being careful to ligate the tributary vessels before removing the growth. Skin-grafting is frequently necessary to avoid the formation of contracting scars. Hot-water injections, after the method of Dr. John A. Wyeth, have been successful.

Dermoid cysts are occasionally found upon the lids at the outer angle of the orbit or the brow, and differ in no manner from dermoids in other portions of the body. Such a cyst presents itself as a soft, fluctuating tumour without inflammatory symptoms, and the usual contents—sebaceous matter, hair, etc.—may be demonstrated upon opening the cyst-wall.

The treatment consists in removal of the entire cyst-sac, or, in the event of its having already been opened, a sufficient portion of the cyst-wall should be excised to prevent its refilling.

Verrucæ or *warts*, and similar dermal hypertrophies, may occur upon the lids, the most frequent of which is the filiform wart,

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a slender, thread-like outgrowth. These may be conveniently removed by ligation, followed by cauterization of the base with glacial acetic acid. Electrolysis may be substituted for ligation.

Sarcoma, in rare instances, may occur as a primary growth upon the lids, and is characterized in the beginning by a pea- to hazel-nut-sized or larger, firm, elastic tumour. It may or may not be pigmented. Non-pigmented sarcomas may be mistaken for chalazions, but the history and subsequent course serve to distinguish these affections.

The treatment consists in early excision on account of the malignant character of the disease.

Zanthoma, zanthelasma, or *vitiligoidea* is a cutaneous new growth of the eyelids involving the connective tissue and characterized by circumscribed yellowish patches. It is said to result from fatty degeneration and also from displaced embryonal muscle fibres in the skin of the lids. The growths are flat and smooth, and resemble chamois leather. It is most frequent in middle-aged women, particularly of the brunette type. Usually it is of no importance, as the lesion remains stationary after an indefinite period, but it may be associated with diabetes or jaundice.

Treatment is usually unnecessary, except for cosmetic purposes. Excision, electrolysis, and cauterization may be employed to remove the growth.

Epithelial molluscum, or *molluscum contagiosum,* occasionally affects the eyelids, and is characterized by pinhead to pea-sized, smooth, waxy-white or pinkish elevations containing a central depression or opening. It is a rare condition. The disease is feebly contagious, a period of about six months being required for its incubation. It is self-limited, usually disappearing spontaneously by suppuration and sloughing of the lesions. It is most common in children of the poorer classes. The importance of the affection arises from the fact that microscopically it resembles epithelioma. Cauterization with nitrate of silver or trichloracetic acid suffices in obstinate cases. As a rule, no scarring follows sloughing of the lesions.

Leprosy is found in connection with the eyelids, and appears in two forms, the tubercular and anæsthetic. It is manifested by exaggeration of the normal folds of the skin and loss of the eyebrows and eyelashes due to the infiltration of the leprous cells. Other symptoms, such as macules, tubercles, papules, ulceration, and gangrene are also present. The prognosis is unfavourable and treatment is of very little avail.

Elephantiasis, a chronic disease of the skin and underlying connective tissue manifested by hypertrophy and obstruction of the lymph channels, has also been observed in the eyelids, but is extremely rare. There is a congenital hypertrophy of the upper lid that resembles elephantiasis very closely.

Neuroma, lipoma, adenoma, and *papilloma* occur upon the lids, and should be distinguished from other tumours in this situation. Excision is indicated in each.

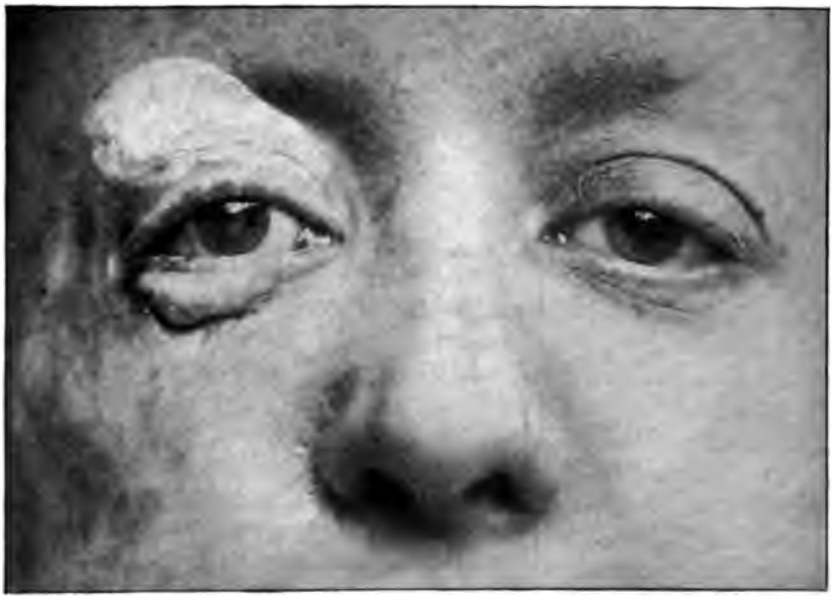

Fig. 24.—Skin-grafting of Eyelids for Cicatricial Deformities Following Severe Burns.

Burns of the Eyelid.—These usually result from sudden contact with hot water, caustics, mineral acids, carbolic acid, cigar ashes, powder explosion, flame, molten metal, etc. Ordinary scalds and burns require the application of sweet oil, carbonate of soda, carron oil, or boric-acid ointment, and a protective bandage. Indolent granulations on the site of a burn necessitate stimulation by balsam of Peru, silver nitrate, etc. The scar tissue that forms gives rise to deformities such as ectropion, entropion, symblepharon, and ankyloblepharon. There is always great danger of the cornea being involved in such cases with irremediable damage to sight.

AFFECTIONS OF THE EYELASHES

Hordeolum, or stye, is a furuncular inflammation attacking the follicles of the eyelashes. It begins as a small red swelling at the margin of either lid, and is attended by tenderness, pain, œdema, and impairment of vision. The affection may subside or remain stationary for an indefinite period, but more frequently it terminates in suppuration, which is indicated by the yellowish point at the summit of the lesion. The cause of styes is the infection of the hair follicles by pus-producing micro-organisms in eyelids congested as the result of refraction errors or some derangement of the general health. They occur at all ages, but are most common in young adults, in whom they often show a tendency to come out in crops.

The treatment varies according to the stage of the inflammation. Attempts may be made to abort the lesion by the constant application of cold compresses, boric-acid solution, and the administration of calcium sulphide (gr. ⅛ three times daily). The benefit derived from such measures in this connection is doubtful. A better method of treatment is to hasten suppuration by the application of hot compresses alone or wrung out in the following solution:

℞ Liq. plumbi subacetatis	ʒij;
Tr. opii, Tr. belladonnæ,	āā ʒiss;
Tr. arnicæ	ʒi;
Aquæ camphoræ, Aquæ destillatæ,	āā q. s. ad. ℥iv.

M.

S.: Poison. Use locally as directed.

The appearance of the yellow spot at the summit of the lesion calls for evacuation of the underlying pus. This may be accomplished by removing the hair in the centre of the stye or by a vertical incision through it. A weak antiseptic dressing should then be applied. Sometimes an ointment containing ichthyol (1 dram to the ounce) seems to be of special value in this condition. In all cases a careful examination should be made of the refraction, as recurrences are common in the presence of ametropia. Tonics, such as iron, quinine, strychnine, and cod-liver oil, are sometimes necessary when the affection persists. The presence of constipation should be ascertained, and appropriate treatment directed towards it, as it is a contributory factor in many cases.

Alopecia areata, a neurotic disease of the hair follicles which induces partial baldness in atrophic areas, sometimes attacks the eyelashes, causing them to drop out more or less suddenly without any local structural change to account for it. The skin is smooth, soft, and of a dead-white colour. The condition is most common in children and young adults, and the hair in these individuals usually returns after a period of three or four months. The new hairs are at first devoid of pigment and resemble down, but later assume their normal characteristics.

The treatment consists in the administration of arsenic in varying doses according to the age of the patient and the local application of the faradic current. The close proximity to the cornea contra-indicates the local application of alcohol, capsicum, cantharides, and similar irritating preparations usually advised for this affection in the scalp.

Pediculosis ciliorum is a parasitic affection of the eyelashes produced by the pediculosis pubis, or crab louse. It is the smallest variety of the pediculi, and is found at the roots of the cilia with the head buried in the follicle. The shafts of the eyelashes are covered with the ova, or "nits," which are fastened very firmly to them. The affection induces itching and burning of a considerable degree, and excoriations of the eyelid result.

The treatment consists in removal of the parasites and their ova. The difficulty attending this procedure is often great, so that it is frequently necessary to remove the cilia themselves. To remove the ova, their gelatine-like capsule must be softened by sweet oil or petrolatum. Solutions of sodium bicarbonate and boric acid are also useful. A weak mercurial ointment may be employed.

Distichiasis is an affection of the margins of the lids in which a double row of eyelashes is present. *Trichiasis* is the term applied to an abnormal position of the cilia. These conditions are nearly always combined, and may be congenital or acquired. The acquired forms are due to inflammatory diseases such as trachoma in most cases. They may also be due to burns and injuries of the lids. The constant irritation of the cornea induces vascularization of that structure in all cases of long duration. Often the misplacement of the hairs, if associated with entropion. The common symptom in these conditions is the complaint of a foreign body, or "wild hairs," in the eye.

The treatment consists in epilation, destruction of the follicle, changing the position, excision, and transplantation. Epilation of the hairs can be easily performed with the aid of cilia forceps, but is unsatisfactory in that the hairs grow out in a very short time. Electrolysis is more satisfactory on account of the destruction that takes place, but is a very tedious process, and often painful. Anæsthetization by the injection of cocaine into the follicle renders it more bearable. In the practical application of the treatment it should be remembered that the needle should be attached to the negative pole and the positive pole should be placed against the temple. Illaqueation consists in withdrawing the misplaced cilia through an artificial opening in the lid by means of a noose. The elasticity of the lashes defeats this operation by allowing them to regain their abnormal position within a short period. The operative procedures devised for this annoying condition also aim to relieve the entropion which is so commonly associated with it, and most of these operations are described under entropion. The more simple operations consist in incision of the lid and excision of a wedge-shaped portion of the skin of the edge of the lid containing the cilia. The simple incision treatment consists in freeing the edge of the upper lid from the lower border of the tarsus along its entire length. In the excision method the lid is split near its conjunctival border, and a V-shaped portion of the skin containing the bulbs of the misdirected hairs is removed. The field of operation is rendered bloodless by some form of entropion forceps, and after their removal hæmorrhage is controlled by pressure over the supra-orbital notch and upon the edge of the lid. The success of this operation is assured if a piece of the integument containing very few hairs is taken from back of the ear, wrist, or arm, or mucous membrane from the lip, and grafted upon the raw surface of the open wound. As this condition is usually associated with entropion, a further description of the operation for its relief will be considered under that subject.

AFFECTIONS OF THE TARSAL CARTILAGE

Inflammation or tarsitis sometimes occurs in connection with erysipelatous inflammation of the lid. It may also take place as a manifestation of syphilis, and is characterized by swelling and drooping of the lid, which becomes very tense. Distortion of the lid is the usual sequel.

The most common tumour of the tarsal cartilage is enchondroma. The terms tarsal tumour and tarsal cyst have reference to chalazion, a cyst of the Meibomian glands.

AFFECTIONS OF THE MUSCLES OF THE EYELIDS

The most important affections of the muscles in this situation are spasm and paralysis. The spasmodic conditions are nictitation and blepharospasm, and the palsied conditions are ptosis and lagophthalmus.

Nictitation consists in frequently repeated involuntary winking, and constitutes the so-called " life " of the eyelid. It results from a clonic spasm of the orbicularis muscle induced usually by excessive eye-strain. Neurotic conditions such as hysteria, chorea, neurasthenia, etc., may also give rise to it. The instillation of eserin in the eye sometimes occasions this condition.

The treatment consists in the administration of remedies indicated by the underlying neurotic condition and a thorough examination of the refraction under atropine mydriasis.

Blepharospasm is a tonic contraction of the orbicularis palpebrarum. One or both eyes may be attacked, causing the patient to be blind during the period of the spasm. It is a reflex condition and attends irritation of the cornea and conjunctiva. Foreign bodies in these structures and phlyctenular disease are always accompanied by it. In some cases irritation of the facial or trifacial nerves may induce it and may be relieved by pressure over the styloid foramen or the supra-orbital notch respectively. Obscure cases are attributed to hysteria and central irritation of the nerves.

The treatment in the majority of instances should be directed towards the local condition in the cornea and conjunctiva, as it is in these structures the cause usually resides.

Ptosis, or blepharoptosis, is a condition in which the upper lid droops and hangs over the eyeball. It is always due to injury or disease involving the third cranial nerve, particularly in its distribution to the *levator palpebræ superioris,* but the conditions that give rise to such affections may be congenital or acquired. In some cases drooping of the lid is due to increased weight, as is seen in various inflammatory affections of the lid, and also to an increase in the adipose tissue of the lid. It may also occur as a result of senile atrophy of the levator palpebræ muscle, and in such instances is bilateral. These last-mentioned varieties are not generally considered as cases of true ptosis.

In congenital cases of ptosis, it has been observed that elevation of the drooping lid occurs in abduction and adduction of the eyeball and when the mouth is opened. Contraction of the pupil occurs synchronously with these movements. Various explanations have been advanced for these associated movements, none of which, however, are satisfactory.

Ptosis may be of value as a localizing symptom in cerebral disease, and its relation to the brain should always be borne in mind. It is of no value in locating cortical lesions, but its presence may serve to distinguish cortical lesions from those situated elsewhere in the brain. As an example may be mentioned monolateral ptosis which, when unaccompanied by other focal symptoms, points to the existence of a focus of injury or disease in the cortex alone. In disease of the pons, ptosis may occur on the same side as the lesion independent of involvement of other points of distribution of the third cranial nerve. Its relation to crossed paralysis also cannot be ignored, as localization of a brain lesion may be greatly aided by its presence and character. In disease of the crus cerebri it is common to find the entire third cranial nerve palsied, but paralysis of the branch supplied to the levator palpebræ alone indicates a lesion of the cerebral peduncle.

Pseudo-ptosis is a rare form of the affection, which is not due to palsy of the third nerve, but seems to be a part of a unilateral vaso-motor paresis. It is accompanied by elevation of temperature, redness, and œdema of the paralyzed side, drooping of the lid with the retention of the ability to raise it, miosis, apparent shrinking of the eyeball, and an abnormal lacrymal, nasal, and salivary secretion of the same side. According to Nothnagel, the condition is associated with disease of the corpus striatum.

The paralytic forms of ptosis may be of central or peripheral origin. Those of central origin are due to the various forms of cerebral syphilis, brain tumour, or hæmorrhage. The peripheral variety results from exposure to cold and wet when overheated, rheumatism, or syphilitic diseases of the third cranial nerve.

The treatment in all cases should be at first medicinal. Mercury and the iodides, salicylates, and tonics should be administered to their physiological limit. Bandaging of the eye should also be performed. Strychnine should also be given internally to its point of tolerance, and galvanism should be employed. If there is no response to internal treatment after a fair trial extending over eight to twelve months, some form of operative procedure may be performed, bearing in mind that the natural elasticity of the skin is likely to defeat the purpose of the operation.

If the lid droops so that vision is impaired, a small spring appliance made out of gold wire may be used, which presses gently into a fold of the skin with only strength enough to elevate the lid, but not enough to prevent its closing.

The most simple operation for this condition consists in excising a fold of the skin and sometimes the muscle in the long axis of the lid, and suturing the edges of the wound.

Birnbacher's operation necessitates the making of a curved incision with its convexity upward in the skin directly over the upper edge of the tarsal cartilage. Three sutures carrying two needles each are introduced through the upper border of the tarsus. Three loops should then be formed in the cartilage. The needles of the central loop should be passed vertically upward under the skin, and should emerge in the eyebrow very close to each other. The lateral loops are introduced in a similar manner, but diverge from the central loop. The sutures should be adjusted and fastened over a small roll of lint or adhesive plaster to prevent their pulling through, and may be left in place for two or three weeks.

Everbusch's operation was especially devised for the relief of congenital ptosis, and aims to advance the insertion of the levator palpebrarum. The lid should be clamped and the skin divided the whole length of the lid parallel to its free margin midway between the brow and the ciliary margin. A free dissection is then made to expose the insertion of the levator, which is about 5 millimetres below the upper margin of the tarsus. A suture carrying two needles is introduced into the muscle at its insertion so as to include about 2 millimetres of its tendon. The needles are then carried downward between the orbicularis and tarsus to the ciliary margin, where they emerge at a distance of about 2 millimetres from each other, the ends being fastened over glass beads. A nasal and a temporal suture are introduced in the same manner.

Ferguson's operation is performed by making an incision 1 to 1.2 inch long over the orbital ridge. A portion of the occipito-frontalis muscle is dissected free and brought down between the tarsus and the skin to the margin of the lid, where it is fastened by means of sutures. The contraction of the frontalis serves to elevate the lid.

Gillet de Grandmont's method of relieving congenital ptosis consists in the excision of a portion of the tarsal cartilage together with the removal of a portion of the tarso-orbital fascia and the levator muscle. The fascia and the tarsus remaining are then sutured by means of catgut.

Gruening's operation is a modification of Grandmont's method, and depends upon excision of a portion of the tarsal cartilage. An incision should be made through the skin and muscle of the upper lid parallel to its border and 3 millimetres distant from it. The entire tarsal cartilage is exposed, and a portion measuring 2 millimetres in height at each end and 6 millimetres in the centre is excised. A silk thread armed with two needles is then passed through the orbito-tarsal fascia and the free margin of the upper lid just above the eyelashes, where the free ends of the silk are tied. This serves to maintain the apposition of these two surfaces, and is greatly re-enforced by the introduction of 3 such sutures. The skin wound is sutured by silk. The sutures should be removed at the end of four days.

Motais has devised a ptosis operation in which a tongue-shaped flap is resected from the centre of the tendon of the superior rectus and sutured to the fascia beneath the palpebral conjunctiva.

Mules's operation is more difficult. It requires clamping of the lid by means of an entropion clamp, after which the edge of the tarsus is grooved near its centre behind the follicles of the cilia for about ⅓ of an inch. The clamp is removed and the lid is drawn tense by means of forceps. A wire suture carrying two needles is then introduced. At each end of the groove a needle is passed upward for about half the width of the lid in the centre of the tarsus, and is then thrust forward and outward through the tarsus and skin, the wire being drawn through the incision made at the beginning of the operation. Ptosis needles, especially designed for this purpose, should be pushed deeply from the brow, separated by an interval of about 1.4 of an inch, undermining the skin of the eyebrow and lid to the incision, through which the wire has already been passed. The wire is then removed from the needles first used and threaded upon the ptosis needles, which are then withdrawn through the openings in the skin of the eyebrow, where the ends of the wire are fastened after proper adjustment of the lid.

Pagenstecher's method consists in passing a suture in the form of a loop from the eyebrow close to the margin of the lid, where the ends are tied. It should then be tightened more and more upon each succeeding day. The success attending this operation is not so great as has been claimed.

Panas's method consists in uniting a fold of the skin of the eyelid with the frontalis muscle on the forehead. For the accurate adjustment of the flap it is absolutely necessary that the skin of the forehead should be held firmly by an assistant throughout the entire operation. A horn spatula should be introduced beneath the lid and a horizontal incision made 1 inch in length extending to the periosteum directly over the orbital margin. A second incision should be made along the upper border of the eyebrow, and the tissue between these incisions is freed from its underlying attachments. A flap is dissected up on the lid from the first incision to the ciliary margin, avoiding the suspensory ligament of the lid. The flap is then drawn upward under the bridge of tissue and fastened to the upper margin of the high incision. Ectropion is avoided by the introduction of lateral sutures which include the conjunctiva and suspensory ligament, but exclude the skin. These are also secured to the upper incision.

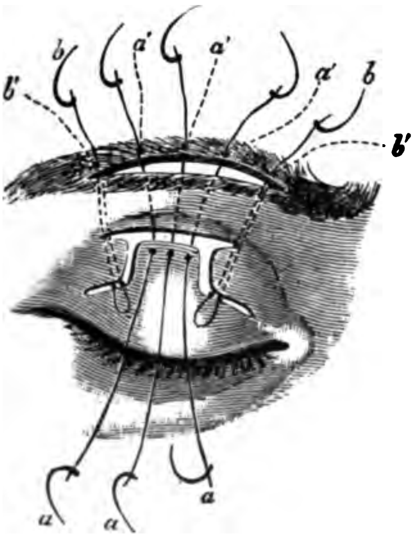

FIG. 25.—PANAS'S OPERATION FOR PTOSIS.

Allport, of Chicago (Journal of the American Medical Association, 1903, p. 956), describes a modification of Panas's operation for ptosis, the object of which is to overcome the three principal objections urged against the latter procedure. The first objection is the failure of union between the tongue and bridge flap due to the unbroken skin surface of the former. This is readily overcome by denuding the tongue flap of its epithelium and thoroughly scarifying it before it is dissected from the underlying tissue. The second objection is the thick lumpy appearance of the bridge flap that persists indefinitely after the operation. This is to a large extent prevented by making the bridge flap as thin as possible and restricting its width to 5 or 6 millimetres. The third objection is the unsightly puckering that occurs at either angle of the lid. To remedy this, it is advised to cut off the corners of the side flaps (which are square in the original operation), and to denude them of the tissue underlying the true skin in order to make them as thin as possible. All the sutures are introduced through the tongue flap, as described by Panas, with the addition that two sutures are introduced on either side to unite the sides of the triangular flaps to the adjacent wound edges.

Tansley's operation for the relief of ptosis may be considered as a modification of Panas's operation. The operation is begun by making two vertical and parallel incisions (*AB, CD*) one-quarter inch apart, extending from the upper orbital margin to within two lines of the free edge of the lid. The incisions are united above by a horizontal incision (*AC*), and a rectangular skin-flap is dissected up and covered by an aseptic pad moistened by a warm saline solution. This is followed by making curved incisions from *G* to *H* and from *E* to *F*, following the line of the fold that corresponds to the upper border of the tarsal cartilage. A horizontal incision is then made from *H* to *B* and from *D* to *F* parallel to and about two lines distant from the ciliary border. The skin and orbicularis muscle embraced by these incisions should then be carefully dissected off, exposing the entire tarsal cartilage to view. The cut edges, *H G* and *E F*,

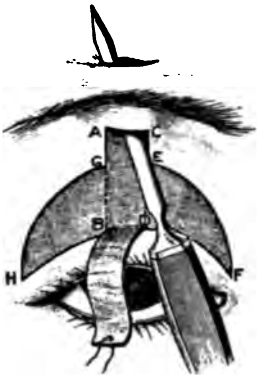

FIG. 26.

are then united by interrupted sutures to the cut edges *H B* and *D F* respectively. A Graefe's cataract knife should be entered at *A C*, emerging on the forehead just above the eyebrow, with sufficient lateral cutting to allow easy passage of the flap formed in the early part of the operation. This rectangular flap is then drawn up beneath the bridge of skin on the eyebrow and fastened by sutures to the upper edge of the brow incision after the necessary elevation of the lid has been determined. Sutures are also placed at *A* and *G*, and *C* and *E* to aid in supporting the flap.

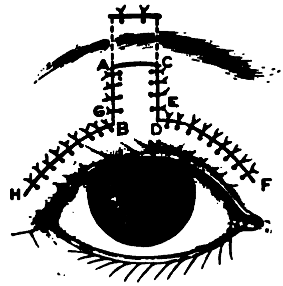

FIG. 27.

Wilder's operation consists in shortening the fascia that extends from the margin of the orbit to the tarsal cartilage by means of buried sutures.

Wolf's operation for congenital ptosis also has for its object the advancement of the levator palpebræ. His first method consists in incising the skin and severing the tendon, after which it is united by sutures of varying depth according to the degree of shortening required. In the second method the operation is performed from the conjunctival surface.

Jessop's operation consists in the subcutaneous separation of the skin of the eyelid from the orbicularis muscle and the introduction of sutures extending from the margin of the eyelid to the brow. In beginning this operation the lid should be stretched and made firm by an entropion clamp (Snellen) or a bone spatula. A von Graefe's knife with its edge upward is introduced through the skin at the outer side of the lid and passed under the skin for its entire length. The knife is then carefully swept round subcutaneously in order to separate the integument from the muscle and other underlying tissues. The knife may be reversed so that the skin is freed as far as the lid margin. A silk suture, threaded with a needle at either end, is then employed. One needle is introduced about 2 millimetres from the ciliary margin at the junction of the outer third with the inner two-thirds of the lid, passed upward beneath the skin, and emerges a trifle above the eyebrow. The remaining needle is introduced 2 millimetres from the first, and pursues a parallel course. At the junction of the inner third and outer two-thirds a similar suture is employed in the same manner. Traction should be exerted upon the ends of the sutures until the desired elevation of the lid is acquired, after which they are tied over pieces of rubber tubing. The sutures should be removed at the end of a week.

Hess's Operation.—The eyebrow is first shaved, after which a curvilinear incision is made in its whole length through the skin and subcutaneous tissue. The skin of the eyelid is then dissected free from the underlying tissue from the incision to near the ciliary margin along the whole length of the lid. Three silk sutures, each armed with two needles, are then passed from without inward through the skin only midway between the eyebrow and lid margin, and are brought out at the upper part of the space made by previous dissection. (According to Lawson, these sutures are of most value when introduced close to the lid margin.) The sutures should be introduced so that each form a loop about 5 millimetres in length, and should be so arranged as to divide the length of the ciliary border equally between them. Traction upon the sutures from above causes the upper lid to become folded upon itself, resembling the normal fold. The needles are then introduced under the brow and emerge a few millimetres above it, where the free ends are tied over a roll of adhesive plaster, after having accurately gauged the amount of traction necessary. A continuous suture is used to unite the brow incision. The lid sutures may be tightened from time to time, if necessary, and are usually left in from eight to ten days.

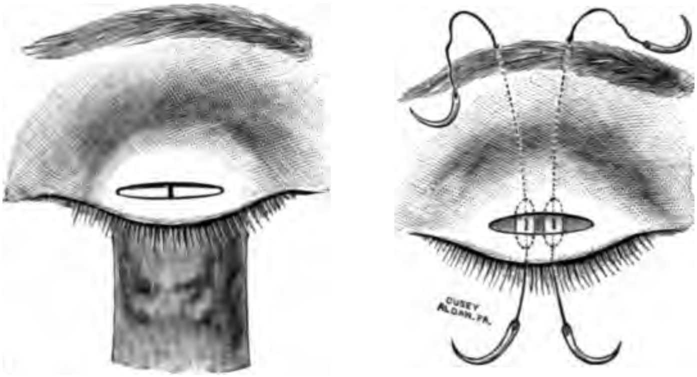

Fig. 28.—Komoto's Operation.

Komoto, Japan (from abstract in Annals of Ophthalmology, April, 1903, p. 364), describes an operation for ptosis, which he has performed for six years with success, that differs in many respects from those usually employed. Two incisions should be made parallel to the free margin of the upper lid, separated from each other by a short space and brought out together at each end, forming an oblong flap 5 millimetres in length. This flap is then divided in the centre and loosened in the medial and lateral direction.

The under side of each flap is then separated to the central part. Two needles with sutures attached are then passed through the ends of each flap. The neighbouring skin is then undermined above to the eyebrow and below to the lid margin. One of the flaps is then turned to an angle of 90 degrees, and one end of the suture is passed under the skin through the eyebrow and the other end to the lid margin. The same procedure is then repeated with the other flap, thus forming two perpendicular skin strips under the skin of the upper lid that should diverge somewhat above. The free ends of the sutures should be tied together at the eyebrow over a roll of adhesive plaster. The sutures are removed at the end of a week. The shrinkage of the flaps aids the efficiency of the operation materially.

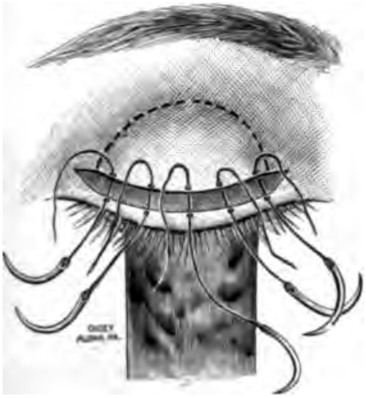

FIG. 29.—AUTHOR'S OPERATION FOR PTOSIS.

The Author's Method.—The affected lid should be drawn down until its edge is directly opposite to that of the lower lid and the extent of the redundant fold of skin is ascertained. An incision is then made across the full width of the lid a few lines above its ciliary margin and parallel to it. A second incision is made parallel to this and at a sufficient distance from it to inclose the excess of tissue between them. This flap is then dissected off by scissors and the skin above the upper incision is freed from its underlying attachments. The margins of the wound are approximated and sutured by interrupted sutures near the free margin of the lid.

No scar follows, and ectropion is avoided by the undermining of the skin of the lid before suturing it to the lid border. The ultimate results are good and permanent.

In selecting an operation for the relief of ptosis the advantages of each operation should receive careful consideration, as no one method is adapted for all cases. Those operations that overcome ptosis most readily frequently leave behind some cicatricial deformity equally disfiguring.

In ptosis, particularly in the paralytic variety, considerable benefit may be derived from the application of a strip of adhesive plaster to the forehead and eyelid to afford support to the latter during the day. It should always be combined with electricity and internal medication, as it is only an adjunct to the treatment.

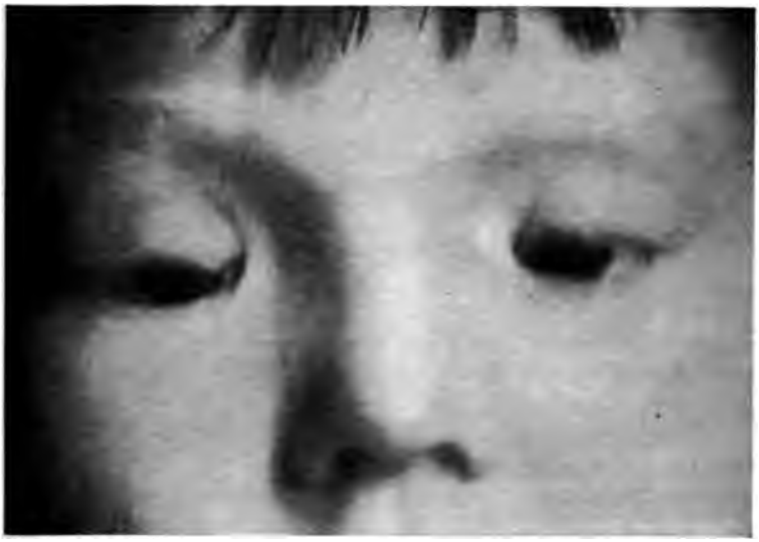

FIG. 30.—CONGENITAL LAGOPHTHALMOS.

Lagophthalmos, or palsy of the orbicularis palpebrarum, is manifested by a distinct inability to properly close the eyelids. It is common in connection with Bell's, or facial palsy, but may be present in conditions of the globe and orbit causing protrusion of the eyeball, as exophthalmic goître, tumour of the orbit, staphyloma, etc. The condition may also result from narrowing of the lids as a consequence of injury, ulceration, or cicatrices. The most marked cases are congenital in origin. The great danger in this affection is the probability of the occurrence of corneal ulceration from the constant exposure of the structure.

The treatment should be directed towards any existing paralytic condition. Galvanism and strychnine should be freely employed, and a bandage should be applied to protect the eye. The operative treatment consists in the performance of tarsorrhaphy. The operation of *tarsorrhaphy* was designed for the purpose of shortening the palpebral fissure when it is abnormally wide and consequently is applicable to conditions other than lagophthalmos. The necessary closing of the lids should be marked upon the skin at the external canthus. A horn spatula should be introduced beneath the upper lid, and a flap, corresponding to the marking, is made from the lids at the external commissure. This flap seldom needs to be more than 1 millimetre in width and 4 millimetres in length, and should contain all the hair follicles in this situation. Sutures are then introduced to approximate the edges of the wound. Sometimes the operation is performed at the inner canthus without removing the cilia in this location. Occasionally the protrusion of the eyeball is so great that suturing of the lids throughout the whole extent of their free margin is necessary.

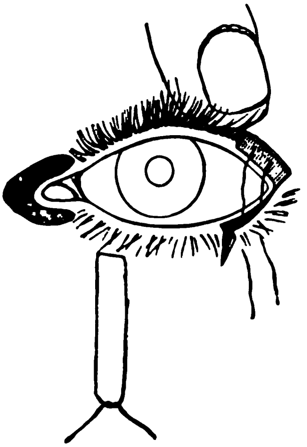

FIG. 31.—TARSORRHAPHY.

A lateral tarsorrhaphy is represented at the external angle of the eye; a median tarsorrhaphy at the internal angle. On the lower lid is shown the position of the loop of thread in Gaillard's suture.

Affections of Meibomian Glands.—The most frequent is that in which the secretion accumulates, and its outflow is retarded by some inflammatory obstruction of the duct of one of the glands. This condition is known as Meibomian cyst, chalazion, tarsal cyst, and tarsal tumour. It may terminate by ulceration through the skin or conjunctiva with partial evacuation of the cyst, or it may become calcified and ulcerate through at a later period. The latter termination is more frequent in gouty individuals, and in such persons these glands are often the seat of tophi. They are most common in adults who subject their eyes to considerable strain in consequence of some error of refraction. There may be one or more present at the same time, and they require a rather long period for the completion of their course. They are first noticeable by the hard swelling beneath the skin and in the upper lid, adherent to the tarsal cartilage. Rupture is indicated by the adjacent inflammation and by the small mass of granulations on the conjunctival surface over the tumour. Occasionally they disappear spontaneously, but usually they induce considerable conjunctival irritation and corneal astigmatism by pressure.

The treatment varies with the size of the cysts. When small the ametropia should be corrected and massage of the lid by yellow oxide of mercury ointment (1 grain to a dram) should be practised once daily at least. Larger ones should be removed. To accomplish this the lid should be fixed by a Desmarre's chalazion forceps, so that the ring blade of the forceps encircles the tumour. The forceps is tightened and the tumour is bisected by a sharp scalpel or a Beer's knife. The contents are evacuated by a small especially devised chalazion curette, at the same time destroying the cyst wall. The incision should be made from that side of the lid to which the tumour seems nearest, and an aseptic dressing and bandage are applied. A favourite method of the author's is to incise the cyst upon the conjunctival surface, after which a small curette is introduced and all the contents are removed and the cyst wall is entirely broken up.

CICATRICIAL DEFORMITIES OF THE LIDS

Under this heading are described those conditions of the eyelids that are caused by the contraction of new-formed scar tissue as the result of burns, injury, or similar destructive affections. It includes entropion, ectropion, symblepharon, and ankyloblepharon.

Entropion consists in the inversion of the margin of the lid, and is usually attended by trichiasis. In most cases it results from scar-formation in the conjunctiva and tarsal cartilage of the upper lid, but may be due to a spasmodic condition of the palpebral portion of the orbicularis, and in such cases the lower lid is involved. The last-mentioned variety of the condition is very common in aged persons, the senile changes in the adjacent tissues seeming to predispose somewhat to it. In entropion due to cicatricial tissue in the lid the underlying cause may be readily found to reside in some condition such as trachoma, burns, injuries, and improperly performed surgical operations. In the second variety, the prolonged use of an occlusive bandage, blepharospasm, and absence of the globe, are important causal factors. It is obvious that in all cases of entropion irritation of the cornea is constant, and injury is probable in the absence of prompt relief. The patient complains of the cilia scratching the cornea, and photophobia, pain, and lacrymation are present.

The treatment is largely operative, although temporary relief may be obtained by simple devices before resorting to surgical means. The application of collodion does good by its contraction when dry. Flexible collodion should not be used, as it defeats the purpose by reason of the oil it contains. The application of a strip of adhesive plaster has also been highly recommended. The operations devised for entropion also aim to relieve the trichiasis which is a constant accompaniment, particularly in the trachoma cases, and in fact it is the displacement of the eyelashes that induces the irritation and other symptoms.

Burow's operation for entropion and also for contraction of the upper eyelids consists in splitting the lid from the inner to the outer canthus. The lid is everted over a horn spatula placed first upon the lid, and an incision made 3 millimetres from and parallel with the free border of the lid. The incision, which is made with a Beer's knife or scissors, along a white line readily seen on the conjunctival surface of the lid, is through the cartilage only. The severing of the attachment between these structures allows the lid to assume a normal position by the elasticity of the superficial tissue. In cases unattended by any abnormality of the eyelashes this operation is curative. In the author's experience it is the best of the many operations devised for this deformity.

Berlin's operation is sometimes employed, and in it the first incision begins about 3 millimetres above the ciliary margin, and extends across the whole length of the lid, dividing its entire thickness. The tarsus is exposed by a free dissection, and a portion of it and the underlying conjunctiva 2 millimetres wide is excised. The wound is closed by sutures introduced from the skin surface, and made to include all the divided structures.

Canthoplasty has also been performed, and is most useful in senile entropion. It consists in division of the external canthus. The conjunctiva at the apex of the wound is then sutured to the centre of the skin incision, after which an upper and a lower suture is introduced to unite the conjunctiva to the upper and lower margins of the wound respectively.

Dianoux's operation consists in making an incision parallel to the free margin of the lid and about 4 millimetres from it after an appropriate lid clamp has been applied. This incision should extend to the tarsal cartilage, but should not penetrate it. An intermarginal incision should then be made, splitting the lid into two portions, as in the Jaesche-Arlt operation. This second incision should be made deep enough to meet the first incision, thereby separating the ciliary portion of the lid in the form of a bridge. A third incision should then be made through the skin about 3 millimetres above the first and parallel to it. The flap included between these incisions is dissected free, so that it is attached only at both ends. The lower margin of this flap is grasped by forceps inserted under the ciliary flap and drawn downward under it, to be fastened by sutures to the margin of the tarsus. The ciliary flap is then drawn upward and its upper margin fastened by sutures to the upper border of the highest incision. The objection to this operation lies in the fact that the fine hairs on the transplanted cutaneous surface may irritate the cornea to a very great degree.

Green's method consists in making an incision in the conjunctival surface of the lid parallel to and 2 millimetres from the openings of the Meibomian glands. This incision should be made through the conjunctiva and tarsus extending the whole length of the lid. A strip of skin 2 millimetres wide is excised from the lid at a distance of 1½ millimetre above the ciliary margin, leaving the muscle intact. A curved needle carrying a suture is then introduced a little to the conjunctival side of the cilia and is brought out just within the wound made in the skin excision. It is drawn through and reintroduced in the wound at its upper margin, and passing deeply backward and upward in front of the tarsus it emerges from the skin about 1 centimetre above its point of entrance. Three sutures inserted in this manner and tied usually suffice to relieve the condition. They should be removed in from twenty-four to thirty-six hours.

Ewing's operation for atrophic entropion of the lower eyelid consists essentially of a longitudinal incision through the tarsal conjunctiva and the tarsus parallel to and from 2 to 3 millimetres distant from the lineof the openingsof the Meibomian glands. The lower lid is everted by a modified Desmarre's chalazion clamp, in which the blades are oval in shape. The spatula blade is set against the dermal surface of the lower lid near the ciliary margin, and moderate pressure is made downward and backward. This induces eversion of the lid, so that the conjunctival surface is engaged by the fenestrated blade at a distance of about 2½ millimetres from the lid margin. The clamp should be fastened firmly and the incision should be made the full length of the lid parallel to its margin, being careful not to cut entirely through the lid. For a satisfactory result the incision should be carried through the tarsus and underlying fascia so as to expose the fibres of the orbicularis muscle throughout the entire length of the wound. After the incision of the tarsus has been complete, the partially detached marginal strip may be turned forward by means of toothed forceps, or by inserting either a single thread near its centre, or two or three threads, after which traction upon these threads will serve to draw the wound widely open and expose the muscle-fibres. The sutures are usually three in number, and are passed through the conjunctival edge of the incision in the standing portion of the tarsus, and then through the marginal strip, being entered at the bottom of the wound between the muscle and the detached cartilage to emerge on the dermal surface in or a very little below the line of the cilia. The needle is then re-entered through the skin in the same horizontal line, about 3 millimetres distant from the first point of exit, and the suture is tied in the conjunctival incision. Any portion of the orbicularis muscle that may remain exposed is covered by the insertion of intermediate sutures connecting the conjunctival edge of the standing portion of the tarsus with the bottom of the wound. The sutures are removed in from three to five days.

Hotz's entropion operation is performed by making a curved incision through the skin of the lid corresponding to the upper border of the tarsus so that each end is about 2 millimetres above each canthus. The edges of the incision are separated and a portion of the orbicularis muscle at the upper border of the tarsus is removed. Three or four sutures are then introduced, passing through the lower margin of the wound, the upper border of the tarsal cartilage, and the orbito-tarsal fascia, emerging from the skin at the upper margin of the wound. This has been further modified by an additional intermarginal incision and by excision of a portion of the skin of the lid.

The Jaesche-Arlt method is perhaps one of the best and most extensively used of these operations. The intermarginal portion of the lid should be divided for its whole length into two portions by an incision about 5 millimetres in depth. The division should be such that the orbicularis muscle, skin, and hair follicles should be anterior to the incision and the tarsal cartilage and conjunctiva should be posterior to it. Another incision should now be made through the skin of the lid parallel to the first, but separated from it by an interval of from 5 to 7 millimetres. A third incision should begin at one end of the second incision, and should be carried upward in a curve, to terminate at the other end of the same incision. This forms a semilunar flap between the two incisions, the height of which varies according to the effect desired, but it is usually 4 to 7 millimetres. The integument forming this flap should then be dissected away and the margins of the wound brought together by sutures.

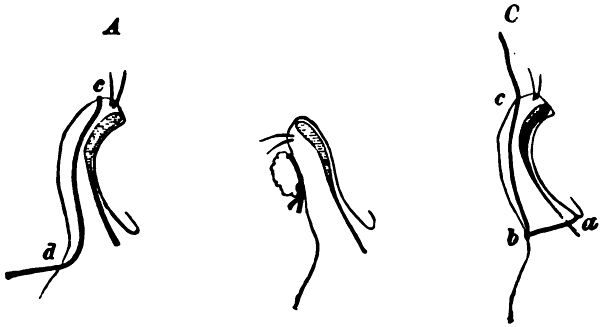

FIG. 32.—METHODS OF OPERATING UPON ENTROPION. Magnified 2 × 1.

A, suture in Gaillard-Arlt's method; mode of applying the loop of thread. B, the same after the loop has been drawn tight. C, suture in Snellen's method.

The Streatfeild-Snellen operation consists in the removal of a wedge-shaped portion of the tarsus. The first incision is made 2 millimetres above and parallel to the margin of the lid for its entire length. The tarsus is then carefully exposed by the excision of a strip of the orbicularis muscle. A triangular-shaped portion, with its apex directed towards the conjunctiva, is removed for its entire length. Sutures are then introduced to bring the edge of the tarsal wound together, but are unnecessary for the skin wound.

Von Graefe's operation is best adapted for entropion of the lower lid. In it a triangular-shaped piece of the skin is excised from the centre of the lower lid with the base at the ciliary margin. The sides of the triangle are then sutured together.

Subcutaneous sutures (*Gaillard's method*) are introduced through the skin at the free margin of the lid and emerging from the skin ¾ of an inch below, where they are fastened over rolls of adhesive plaster. It is most applicable to senile entropion or inversion of the lower lid. The sutures are allowed to slough out, and the subsequent cicatrization brings about cure of the condition.

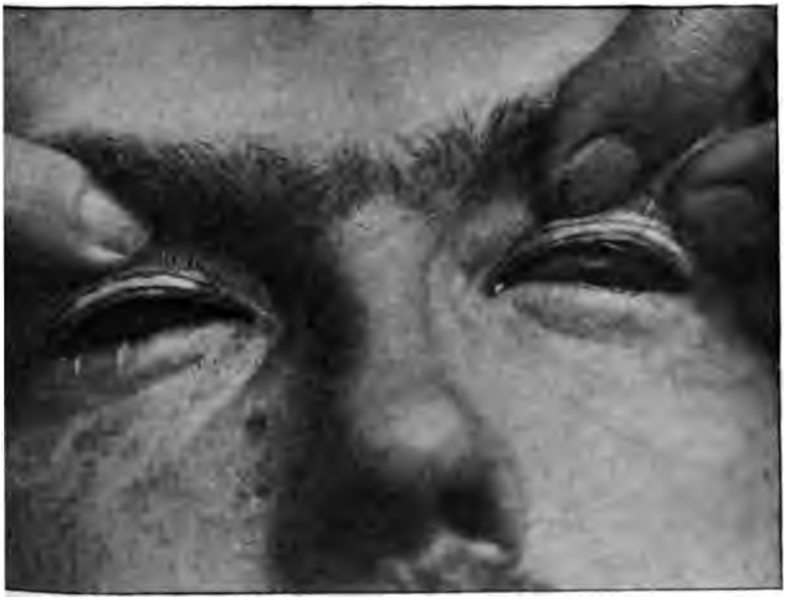

Fig. 33.—Modified Van Milligen Operation for Entropion of Upper Eyelid.

Excision of a horizontal strip of skin and orbicularis sufficient to overcome the entropion, and so that ectropion will not be produced, is recommended in this condition.

It has been the experience of all ophthalmic surgeons that no one or two of these operations is applicable to all cases of this character, and that an operation must be extemporized for each individual case from the principles laid down in these several methods. In a number of cases under my observation a modification of the Burow and the Van Milligen operations, or their combination, yielded me most excellent results. The lid should be split for its entire length at the interciliary margin. A second incision posterior to it is made at the junction of the conjunctiva and the ciliary margin. The wedge-shaped portion of the lid between these incisions is excised, being careful to remove all displaced hair follicles in the resection. A strip of mucous membrane from the lip or a portion of the upper layers of the skin behind the ear is grafted upon the wound. No sutures should be employed. Asepsis in every detail is necessary for a good result in this as in other ocular operations.

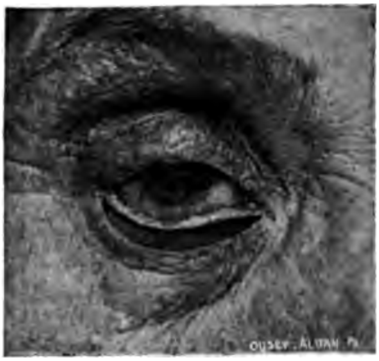

FIG. 34.—OPERATION FOR SENILE ENTROPION.

In all operations for entropion general anæsthesia is absolutely necessary, and the cornea and globe of the eye should be protected by a lid-clamp or horn spatula.

Ectropion, or eversion of the lids, may be of two kinds—muscular and cicatricial.

Muscular ectropion affects most often the lower lid, and is common in old people, as the result of conjunctival œdema and subsequent spasm of the orbicularis muscle. It may also be caused by paralysis of the palpebral portion of the orbicularis.

Cicatricial ectropion is most frequently due to the scars following burns and wounds, but also results from the cicatrices of lupus vulgaris and from caries of the orbit.

The symptoms of ectropion are the result of the constant epiphora and exposure of the conjunctiva and are irritative in character. The term "blear-eye," so commonly applied to this condition by the laity, is particularly descriptive. The treatment is entirely operative.

Adams's operation for the relief of ectropion consists in excision of a wedge-shaped portion of the whole thickness of the lower lid, 5 to 10 millimetres in width at the base at the external canthus. The edges of the remaining wound are then approximated and sutured.

Arlt's method consists in making a V-shaped incision outside of the borders of the scar extending from the inner and outer canthus down the cheek. The scar tissue is then almost completely undermined, and a portion at the apex of the V is shifted to the external canthus and sutured to the margin of the incision in this situation. The exposed surface on the cheek is covered by skin-grafts.

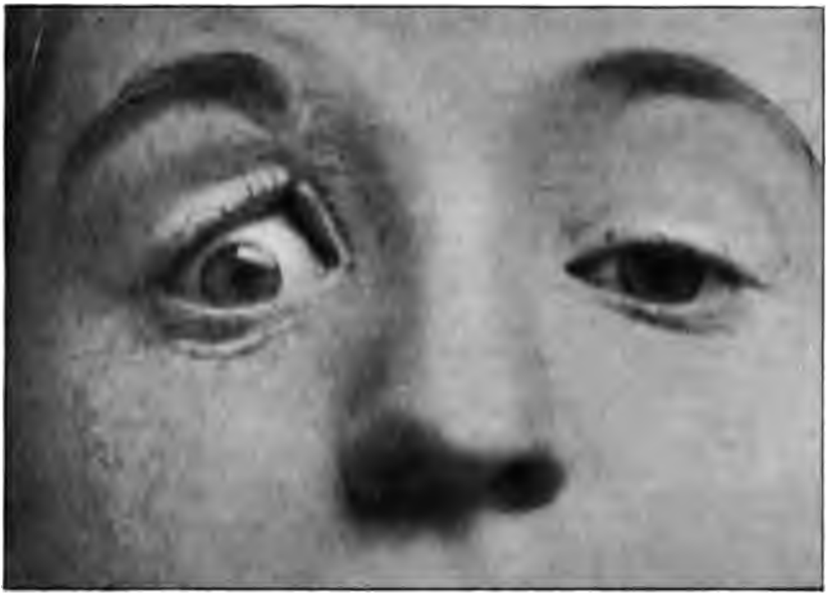

FIG. 35.—CICATRICIAL ECTROPION.

Wharton Jones's ectropion operation begins by making a V-shaped incision outside of the scar inducing the ectropion, after which the skin should be carefully freed from its underlying attachments. The sides of the V are then united by sutures, beginning below, so that the incision is Y-shaped when the operation is completed.

Kuhnt's method is intended to produce shortening of the lid in order to overcome the eversion of the lid. The central third of the lower lid is split and a triangular portion, the base of which is formed by the margin of the lid, is removed from the posterior layer. Three or four sutures are then introduced to approximate the margins of the wound.

Argyll Robertson's operation is best adapted for those forms of ectropion secondary to chronic inflammatory conditions of the conjunctiva. It requires a piece of thin sheet lead (1 inch × ¼ inch), rounded at its extremities and shaped to the curvature of the eyeball, a waxed silk ligature, 15 inches in length, threaded to a curved needle at either end, and a piece of fine india-rubber tubing. The whole thickness of the lid should be perforated by one of the needles, one line distant from the ciliary margin and ¼ of an inch to the outer side of the centre of the lid. The needle is drawn through and passed directly downward over the conjunctival surface until it encounters the lower conjunctival fornix, through which it is pushed and continued downward under the skin of the cheek, emerging from it 1¼ inch below the edge of the lid. The other needle is introduced in like manner ¼ of an inch to the inner side of the centre of the lid and brought out ¼ of an inch from the first, pursuing a course parallel to it. The lead is then passed under the loops that pass over the conjunctival surface of the lid, and the tubing is placed under the loop at the lid margin. The free ends of the ligature are drawn tight and tied over the lower end of the tube. The ligature is allowed to remain in place for about seven days.

Kenneth Scott's operation consists in division of the external canthus, followed by stretching of the margin of the lower eyelid outward and parallel to the border of the upper lid sufficient to restore the normal palpebræ fissure. The portion of the lid with its lashes extending over the external canthus should be removed. The margins of the two eyelids should then be approximated, after which two silver wires are introduced through them to hold them in position. The external canthus is restored by a continuous silk suture, which is allowed to remain for one week. The silver wire should be removed at the end of ten days.

Snellen's Sutures.—A silk ligature carrying a moderately curved needle at either end is required for this operation. It is begun by introducing one of these needles into the everted conjunctiva at its most prominent and exposed portion, and it is brought out through the skin about 2 centimetres below the edge of the lower lid. The other neeedle is introduced in a similar manner 5 millimetres from the first, and emerges on the cheek 1 centimetre from it. Traction should then be exerted on the ligature and the lid pushed into proper position. The ends of the ligature are then tied over a roll of lint or adhesive plaster on the cheek. More than one suture of this character may be required, but none should be allowed to remain for more than four or five days.

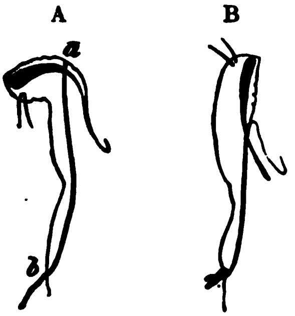

Fig. 36.—Snellen's Suture for Ectropion.

A, before tightening the loop. B, after tightening the loop.

Dieffenbach, Burow, Richet, Fricke, and others have devised operations for the restoration of the eyelid after the removal of contracting cicatrices, as in ectropion, all of which consist in transplantation of a pedunculated flap of skin from adjacent areas. Their great difference lies in the variation in the shape of the respective flaps and the location from which they are taken. Skin-grafting is also of great value. In all these operations, retaining sutures should be introduced from the lid margin and fastened in the brow to hold the lid in position until healing has been completed.

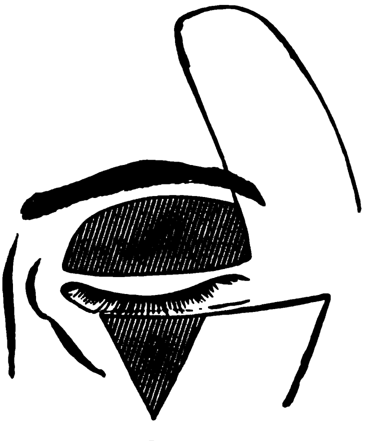

Fig. 37.—Blepharoplasty.

The method of Fricke is represented on the upper lid; that of Dieffenbach on the lower.

Fox Ectropion Operation.—The author has had perfect success by the following method of operation: An intermarginal incision is made the entire length of the lid affected, about 2 millimetres from and parallel with the margin of the lid. The conjunctiva is dissected off and a V-shaped mass of the hypertrophied tissue excised the length of the lid, according to the degree of the ectropion and the amount of tissue present. The edge of the loose palpebral conjunctiva is then trimmed to the required width, when the lid should be placed in normal position and adjusted to the pared surface of the lid. A strong silk ligature, threaded with a long curved needle at each end, is then introduced by one of the needles at a point 6 or 8 millimetres to one side of the centre and 2 millimetres below the insertion of the cilia, and passed through the whole substance of the lid. The needle (after having drawn the thread through the lid a few inches) is passed through the fold of the conjunctiva as it turns upon the globe, and, with a careful estimate of direction, pressed downward through the tissues immediately beneath the skin of the cheek, emerging upon it 1¼ to 1½ inch below the margin of the lower lid. The needle at the other end of the thread is entered about 3 millimetres from the first insertion towards the angle of the eye, and carried through the lid, conjunctival fold, and cheek, parallel to the first. A second thread, with two needles, is used in the same way at an equal distance beyond the centre of the lid on the other side. A bit of rubber tubing is placed under each loop before making tension. The lid is now drawn into proper position by careful tension upon the free ends of the ligature of the cheek, which are then tied over the rubber tubing already mentioned. Within twenty-four

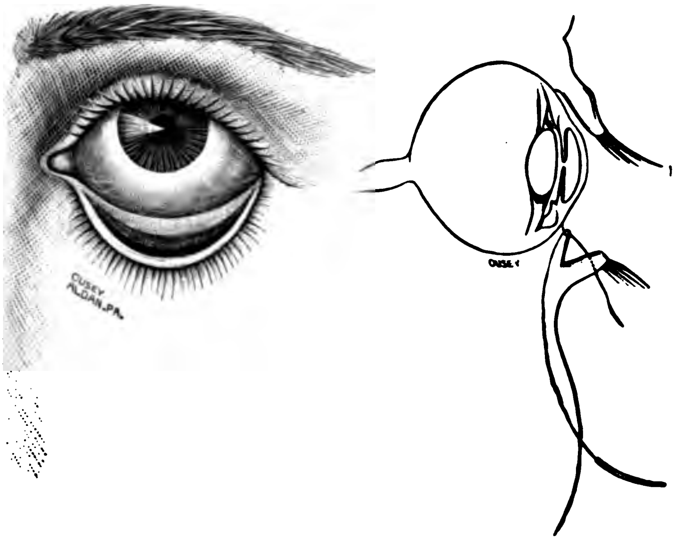

FIG. 38.—FOX ECTROPION OPERATION.

hours the lid will have swollen so that the pieces of rubber tubing can be withdrawn to keep the threads from cutting into the flesh, and within three days the threads may be severed and carefully extracted. No sheet lead is required, the eye need not be bandaged, nor is the occupation of the patient, as a rule, interrupted.

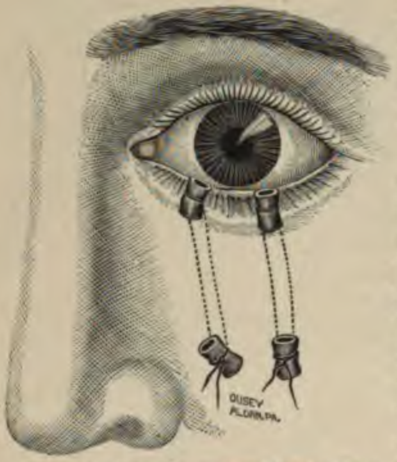

FIG. 39.—FOX ECTROPION OPERATION.

Symblepharon. — The term symblepharon refers to cicatricial union of the eyelids with the conjunctiva of the eyeball. It admits of several varieties in its extent, and may be acquired or congenital in character. In nearly all cases it is the result of burns and injuries of the conjunctiva and lids, particularly when improperly treated, but may be simulated by the scarring that follows the more serious conjunctival inflammation such as trachoma, diphtheritic conjunctivitis, gonorrhœal ophthalmia, and xerosis. Strictly speaking, symblepharon is an abnormal condition of the conjunctiva, but for the sake of differentiating it from ankyloblepharon, which will be discussed later, it is described in this connection. Sometimes the cicatricial attachment between the lids and the cornea is designated as anterior symblepharon in contra-distinction to posterior symblepharon, in which adhesions are formed that bind the under surface of the eyeball at the fornix, leaving the margin of the lid free. The restriction of the ocular movements induced by these bands impair vision in addition to the deformity they produce.

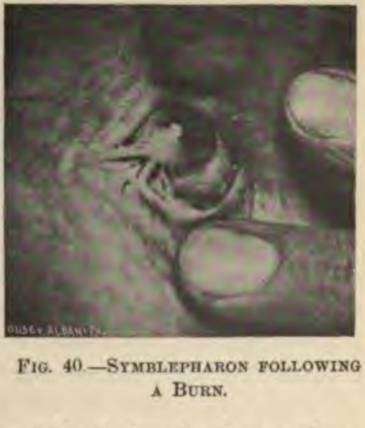

FIG. 40.—SYMBLEPHARON FOLLOWING A BURN.

The treatment is prophylactic and curative. The presence of open wounds of the conjunctiva should be prevented when possible by prompt suturing immediately after such accidents. When already in the granulating stage, the opposing lid surface should be separated from the wound repeatedly at short intervals to prevent union of the bulbar and palpebral conjunctiva. The application of petrolatum containing iodoform or boric acid acts very admirably in this connection. Simple bands of adhesion may be severed by one or two ligatures, according to their breadth, but in more extensive cases more complicated operative procedures are necessary.

Harlan's operation is employed extensively in symblepharon of the lower lid, and has for its object the substitution of a skin surface for the scar tissue formed on the inner conjunctival surface. The whole thickness of the lid should be incised for its entire length along the lower margin of the orbit. A second incision is then made below this in order to form a pedunculated skin flap. After being carefully dissected from all its attachments, except the pedicle, it is turned up through the first incision in the lid and sutured to its under surface, the cicatricial bands having been previously severed. The bare surface remaining upon the cheek is covered by a sliding flap taken from its outer extremity.

Teale's operation consists in making an incision through the attachment of the cicatrix (if it encroaches upon the cornea) corresponding to the corneal margin and dissecting the lid off from the eyeball as far as the fornix. Two flaps are dissected from the bulbar conjunctiva on either side of the cornea, one of which is made to cover the raw surface of the inside of the lid and the other is made to cover the wound on the eyeball. Sutures are then introduced to hold the flaps in position. The formation of a bridge-like conjunctival flap above the cornea and bringing it down to cover the raw bulbar surface has also been suggested by Teale.

Symblepharon may also be relieved in cases of not too great an extent by dissecting the conjunctiva from the cornea and turning it down so as to form the inner surface of the lid, to which it is fastened by sutures.

Transplantation of the conjunctiva from the eyes of animals and the mucous membrane from other portions of the patient has been employed with success.

Ankyloblepharon.—A condition in which adhesions form between the edges of the eyelids. It is due to union of these margins as the result of burns or other granulating surfaces. Symblepharon is frequently associated with it. Blepharophimosis is also applied to the condition of ankyloblepharon, but refers rather to the abnormal narrowing of the palpebral fissure. Usually this is about 26 millimetres long and 1 centimetre high, any departure from which is abnormal. A congenital narrowing of this fissure is sometimes observed.

The treatment is always surgical and requires separation of the lids, after which the bare surfaces should be covered with skin or mucous membrane. The operation of canthoplasty, in which the lids are separated from each other at either or both angles and the opposing edges of each lid are sutured together, is well adapted for this condition.

CONGENITAL MALFORMATIONS OF THE EYELIDS

The various deformities already described, such as ptosis, symblepharon, ankyloblepharon, blepharophimosis, and lagophthalmus, may be of congenital origin, and are probably the most frequent of these conditions. The less common malformations are complete absence (ablepharia totalis), partial development (ablepharia partialis), absence of sufficient covering of the lids, cryptophthalmus (in which the orbital integument is prolonged and covers a partially developed eyeball), coloboma, or fissure of the lid, and epicanthus, in which there is an abnormal crescentic fold of skin at the inner canthi.

Epicanthus is rather frequent, particularly in the Chinese, and requires division of the canthus (canthotomy), with subsequent suturing of the wound edges on each lid. The grafting of skin or mucous membrane in this situation (canthoplasty) is often necessary.

Wounds and injuries of the palpebral conjunctiva and lids are frequent as the result of various forms of traumatism. They require prompt treatment based upon aseptic surgical principles, with a view to prevent the presence of any open granulating surface, as the new connective tissue thus formed leads to troublesome deformities.

Blepharoplastic Operations.—Such operations are required to relieve various cicatricial deformities and for the restoration of the eyelids after severe injuries resulting in their destruction. The individual operations for these conditions have been described elsewhere, but the principles underlying them will be considered under this heading. A general anæsthetic is required in all these operations, and the field of operation should be rendered as aseptic as is compatible with the vitality of the tissues. The cornea and the globe of the eye should be protected by some form of lid clamp or horn spatula when the presence of these instruments does not interfere with the operation. All scar tissue should be carefully dissected away and hæmorrhage promptly controlled. Sutures should always be introduced in such a manner that the ordinary tension incident to opening and closing of the eye will not cause them to tear out. In the event of grafting of skin after the method of Thiersch, or of conjunctiva or other mucous membrane, all hæmorrhage from the raw surface to be grafted should have completely ceased. The grafts should be of the same size as the area upon which they are placed, and require no suturing. Dressings should be applied that will keep the temperature of the area operated upon above that of adjacent structures. Sutures, applications, dressings, etc., should be prepared in conformity with the generally accepted aseptic principles.

CHAPTER IV

DISEASES OF LACRYMAL APPARATUS

THE connection between the nasal passage and the eye afforded by the nasal duct predisposes it to inflammatory conditions by extension of like affections from the nasal or ocular mucous membrane, so that it is inflamed to a greater or less extent in all affections of these adjacent structures. As a result of the congestion and thickening of the mucous membrane, the calibre of the duct is lessened sometimes to a considerable degree, so that the tears are obstructed and flow over the lower lid and down the cheek, constituting epiphora.

Epiphora (*Stillicidium lacrimarum*, watery eye).—The overflowing of the tears upon the cheek. The secretion of the tears is continuous, and their drainage into the nose should be such as to allow but a very small quantity to remain in the conjunctival fornix. From this it may be easily seen that epiphora may result from excessive secretion, obstruction, displacement, or absence of the puncta, canaliculi, lacrymal sac, or nasal duct, or some abnormality of the eyelids.

Excessive secretion of tears may result from emotional disturbances, inflammatory or irritative disorders of the conjunctiva, cornea, or lids, eye-strain, etc.

The affections of the lacrymal apparatus likely to induce it are: eversion of the punctum, such as occurs in ectropion of the lower lid; obstruction of the puncta and canaliculi as the result of foreign bodies, injuries, burns, or inflammatory exudates; and absence or obstruction of the lacrymal sac or nasal duct by calculi, foreign bodies, strictures, etc.

Among the abnormalities of the lids that are accompanied by epiphora may be mentioned ectropion of the lower lid, symblepharon, etc. Ectropion may be due to cicatricial contraction of the lid, senile changes, or paralysis of the orbicularis muscle. The last condition, paralysis of the orbicularis, is most frequent as a part of a facial palsy, and is often the only prominent symptom of such a condition. Its importance arises from the fact that it is likely to be mistaken for some obstruction of the nasal duct and improper treatment instituted. Overlooking the existence of a facial palsy in connection with epiphora, while not a grave error, is a very embarrassing mistake, as the condition persists after treatment directed towards the eye or its appendages.

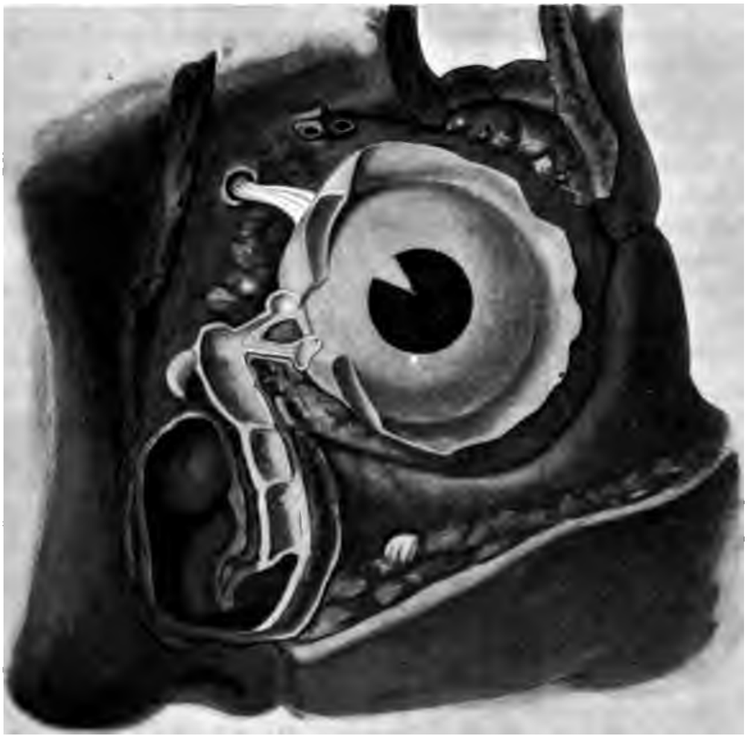

FIG. 41.—LACRYMAL APPARATUS.

Treatment.—The measures adopted for this condition take into consideration the various causes from which it may arise. The condition of the cornea and conjunctiva should be ascertained and appropriately treated. Not infrequently particles of dust or foreign bodies may induce an excessive secretion of tears with their subsequent overflow upon the cheek, and in all cases a careful examination should be made to determine the presence of such foreign substances. An element of eye-strain being present in nearly every individual, the refraction should be examined, but the prescribing of correcting lenses should be left to the judgment of the attending ophthalmologist. In most cases correcting lenses should be worn, as they not only lessen the accommodative effort and subsequent congestion, but are protective in that they prevent to a large extent the contact of irritants with the conjunctiva and cornea.

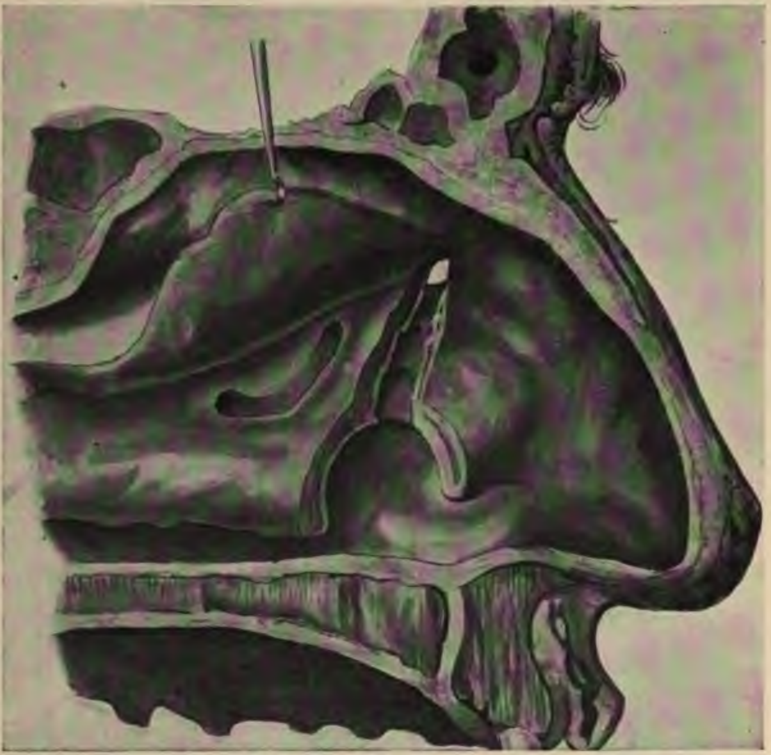

FIG. 42.—NASAL DUCT, OPENING INTO NASAL CAVITIES.

Deformities, displacements, and obstruction of the lacrymal apparatus require surgical interference for their relief. Deformities and displacements always necessitate some operation by which the opening of the punctum is placed in its proper position and the canal from it to the lacrymal sac made patulous. This varies according to the character of the underlying structures.

Obstruction to the nasal duct is more common, and, to a certain extent, difficult to permanently relieve. Often relief may be afforded by dilating the duct with a fine-pointed probe.

The occurrence of a stricture or purulent inflammation in the nasal duct always requires more radical measures. The presence of these conditions in the duct necessitates first the slitting of the lacrymal canaliculus by means of a Weber knife, after which the duct is dilated to its greatest width by silver probes. A gold cannula should then be inserted, guided by a probe specially adapted for this purpose. This cannula should not be allowed to remain undisturbed indefinitely, but should be raised and lowered from time to time to prevent filling up of its interior and the formation of adhesions. Unless prepared to elevate the tube in a certain manner, the raising of it is not only painful, but extremely difficult to perform. It must be remembered that in cases in which the nasal duct has been rendered patulous by the introduction of a gold cannula, the margins of the canaliculis slit by the Weber knife show a tendency to unite over the mouth of the tube; but if the stricture is still present and the obstruction persists, this union occurs with less frequency. The mouth of the cannula should then be freed first before any attempt is made to raise it, and its shelf should be directly forward so as not to wound the conjunctiva or eyeball. A probe, on the end of which is a hook resembling in every detail a crochet needle, is passed completely through the cannula and is raised, keeping in close contact with the cannula until the hook catches upon the lower edge of the tube, after which the hook and cannula are gently drawn upward.

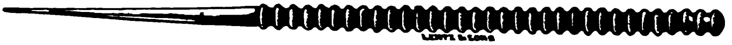

FIG. 43.—PUNCTUM DILATOR.

The slitting of the canal and passing the knife downward, while apparently a simple operation, is, however, not entirely free from danger, since false passages are easily made, or the knife may become wedged in the bony wall and break. In cases where there is pronounced swelling and œdema of the lids, it is better to use an antiphlogistic lotion for several days before operating.

In the whole range of ophthalmic surgery no class of cases gives more trouble and annoyance to the surgeon, and more discomfort to the patient. They are practically never cured; the least exposure to colds or draughts of air causes the tears to flow over the margins of the eyelids, and in many cases produce eczematous eruptions on the cheeks. The presence of pus in the lacrymal sac causes not only an inflammation of the nasal cavities, but also of the conjunctiva, and this condition leads to radical changes in the delicate tissues of the eyelids and Schneiderian membrane of the nose. Not only is the appearance of the eye repugnant, but the foul odour from the diseased bone in the nasal cavity is most offensive, and renders these unfortunate patients objects of sympathy.

As regards treatment in general, mild astringent washes do good in certain cases, as do also dilatation of the puncta or of the whole canal, and syringing, as first suggested by Anel in 1712; but these methods number a failure for every cure. The modern treatment, as practised by the French and German ophthalmic surgeons, consists in the introduction of fine probes, which do not dilate the canal to any extent, while on the other hand, many of the English surgeons dilate the canal to its full calibre. In this country ophthalmologists are divided in opinion as to which is preferable. The author's experience leads him to believe that passing the larger size produces the best results, and he immediately follows it by the introduction of a gold cannula.

AFFECTIONS OF THE LACRYMAL GLAND

Dacryoadenitis.—An inflammation of the lacrymal gland.

This condition is of rare occurrence, and is commonly secondary to other conditions, being caused by sympathetic irritation from neighbouring tissues due to cold, compression, traumatism, syphilis, etc.

It usually assumes a chronic form, giving rise to redness and swelling of the upper lid, and injection of the conjunctiva. It is often associated with certain fevers, with mumps, syphilis, gonorrhœa, rheumatism, and septic absorption. Acute inflammation often goes on to suppuration, attended with enormous swelling of the lids and adjacent tissues. The chronic form is generally painless, and the part is not sensitive to touch, while the acute type may be exceedingly painful. In the chronic form a firm tumour may easily be felt on palpation at the upper and outer margin of the orbit.

Treatment.—The usual antiphlogistic remedies should be tried. In the early stages of the acute form, the application of cold compresses may be effective. Should suppuration be inevitable, thorough evacuation of pus by a free incision in the lacrymal gland, through the upper lid, should be effected at the very first evidences of fluctuation. The wound should, of course, be treated under antiseptic precautions. The danger of an obstinate fistula should also be borne in mind. The chronic form, or hypertrophy of the gland, may be treated by the local application of tincture of iodine. The integument over the part should be kept irritated, if the treatment is to be effective. Iodides and iron should be administered internally, in the hope of causing absorption of the tumour mass. In chronic hypertrophy, its excision may have to be performed. If the condition is due to syphilis, inunctions of mercury and the usual antisyphilitic treatment are indicated.

Atrophy and **hypertrophy** of the lacrymal gland are among the very rare conditions to which that structure is liable. Atrophy is nearly always associated with *xerosis* of the conjunctiva, and is also believed to be a sequel to destruction of the lacrymal sac. Hypertrophy of the gland is the result of repeated inflammatory attacks, or it may be congenital. It is characterized by a firm, elastic, and nodulated enlargement. The increase in size is very slow and may lead to displacement of the globe or limitation of its movements. It is most frequent in children, and when very large should be removed.

Syphilis of the lacrymal gland is very infrequent and is characterized by a painless and non-inflammatory enlargement of the gland. It may be mistaken for hypertrophy or some morbid growth of this structure. The diagnosis is made by the therapeutic test alone, so that in every case of enlargement of the gland mercury and the iodides should be given a fair trial.

Tumours of the lacrymal gland are of uncommon occurrence, but deserve passing mention. The structure of the gland seems to predispose to adenoid growths, as these are most frequent. The lacrymal canals, by reason of their situation, are sometimes occluded by calcareous concretions or dacryoliths, which cause an accumulation of secretion in the gland, a condition known as dacryops.

Epithelioma, osteochondroma, lymphoma, sarcoma, tubercle, chloroma, etc., have been reported, and their presence has necessitated removal of the tumour in every case, and sometimes the entire gland.

Dacryops in reality is a retention cyst of the lacrymal gland, and may be congenital, or it may arise in the manner just described. It occurs as a semitransparent swelling of a bluish white colour, and elastic in character. Fluctuation is easily detected. There is bulging of the palpebral conjunctiva of the upper lid, which is unduly prominent. The swelling is increased by anything that tends to increase the function of the gland. The occlusion of the canals is not always complete, so that a few drops of fluid may be expressed. The treatment of dacryops aims at the restoration of the communication between the gland and the conjunctival *cul-de-sac.* Incision of the cyst wall will bring about temporary relief, but requires constant attention. A ligature may be thrown around a portion of the gland from the conjunctival surface of the lid towards which it is allowed to ulcerate through, thereby establishing a fistula.

Injury to the lacrymal gland may result in displacement of fistula. Displacement of the lacrymal gland may also occur spontaneously, and in either case appears as a soft, movable tumour under the upper lid. In some cases interference is contra-indicated, but usually efforts should be made towards reposition. As a last resort, the gland may be excised. Fistula usually results from injury, but may arise from the rupturing of an abscess. Cauterization may be employed in order to effect its closure, or a plastic operation may be performed. A better plan, however, is to introduce a suture into the gland from the conjunctival surface of the lid, causing it to emerge on the same surface, after which the ends are tied. As the suture ulcerates through the gland a new fistulous tract is formed which opens into the conjunctival fornix and affords free drainage. The original fistula then closes of its own accord, or after very little treatment.

Affections of the Lacrymal Puncta and Canaliculi.—In most anomalous conditions of these portions of the lacrymal apparatus it is the lower punctum and its canaliculus that are at fault, and to obtain a satisfactory conception of these affections one must recall the fact that normally the lower punctum is directed backward and upward towards the eyeball. The occurrence of eversion causes it to be directed forward and outward from the depression at the inner canthus in which the lacrymal secretion accumulates.

As a result the tears do not find their natural channel of drainage and flow over the cheek, constituting epiphora, already described in detail.

It is customary to consider affections of the puncta and canaliculi as being congenital or acquired in character.

The principal congenital conditions consist of an excess or absence of the puncta or canaliculi. The presence of more than one punctum or canaliculus is seldom of any disadvantage, but may induce considerable embarrassment in introducing any instrument if their presence were unknown to the operator. The absence of these openings is more serious, as epiphora is constant until a free communication is made with the nasal duct. The making of an opening is indicated in these cases.

Acquired affections include displacement and obstruction. Displacement of the puncta and canaliculi may arise from any cicatricial contraction of the conjunctiva or eyelids and from paralytic conditions of the eyelids. Obstruction may be brought about by the presence in the punctum or canaliculus of an eyelash, foreign body, leptothrix accumulation, polyps, calcareous concretions, etc., or by inflammatory thickening.

Treatment.—The removal of any foreign body and the restoration of the condition of the conjunctiva and eyelids to normal should be considered first in the treatment. If the condition still persists, relief may be afforded by splitting open the lower canaliculus with Weber's probe-pointed knife in a manner to be described in detail later. In one case, due to congenital absence of the punctum in the author's experience, it was necessary to open the inferior duct and make an artificial punctum.

Affections of the Lacrymal Sac and Nasal Duct.—The chief affection that is liable to attack the lining membrane of the lacrymal sac and nasal duct is inflammation, acute or chronic in character, known as dacryocystitis.

Dacryocystitis is also known as mucocele, blennorrhœa, swelling of the lacrymal sac, etc., according to the nature of the inflammatory attack.

In the acute form, in addition to the œdema, swelling, redness, pain, tenderness, etc., there is epiphora due to the inflammatory swelling within the lacrymal sac and nasal duct, and the obstruction to the tears induced by it.

Acute dacryocystitis is rarely a primary affection. It usually follows upon a chronic inflammatory condition of the mucous membrane whereby strictures are formed. The tears are obstructed in their passage and retained, undergoing pathologic changes. The secretions become infected by micro-organisms present in the conjunctiva or in the nasal passages. It is possible to demonstrate the presence of various forms of rhinitis in nearly all these cases. Diseases such as small-pox, measles, scarlet fever, syphilis, etc., are not uncommonly followed by lacrymal disorders on account of the frequency with which the upper air-passages are involved during their course. Nasal tumours, growths of the antrum of Highmore, actinomycosis, injury, and congenital asymmetry of the face deserve mention, as they are occasionally enountered as causes.

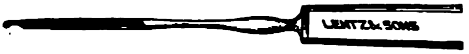

FIG. 44.—WEBER'S KNIFE.

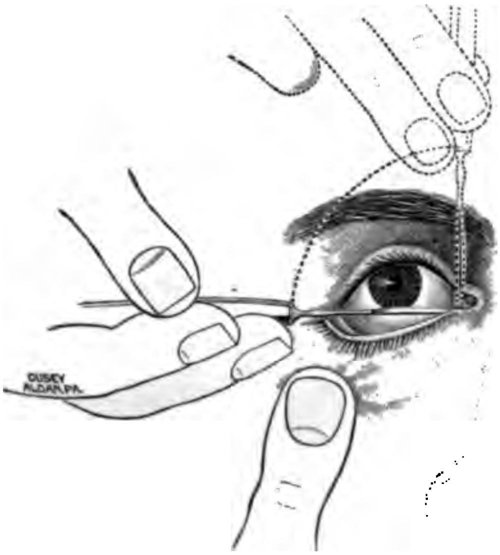

FIG. 45.—BOWMAN'S OPERATION.

The affection is usually phlegmonous in nature, and suppuration occurs early in its course. Fever and chills mark its onset. The lids and side of the nose soon become red and tender to touch, and an erysipelatous swelling soon makes its appearance. The cellular tissue overlying the sac and duct often become affected coincidently, and the resulting abscess points near the tendo-oculi. If prompt and appropriate treatment is not instituted in this stage of the affection, the abscess ruptures and a fistula results. This is easily detected by the prominent granulations that surround its opening.

Inflammation of the tissues over the lacrymal sac and nasal duct may occur independently of any disorder within these passage-ways, and has been termed *prelacrymal abscess.* Pus forms and fistulas may result. It may be due to injury or syphilitic bone disease.

Chronic dacryocystitis is catarrhal in character, and usually results from extension of some catarrhal affection of the nasal mucous membrane. Epiphora is its chief symptom. Its importance arises from the frequency with which acute exacerbations, with suppuration, follow the obstructions it produces.

The acute form may be confused with erysipelas or prelacrymal inflammation; but the appearance of pus or muco-purulent material at the punctum on pressure will serve in most cases to locate the seat of the trouble.

Operation.—The details of the operation on the lacrymal apparatus are carried out as follows:

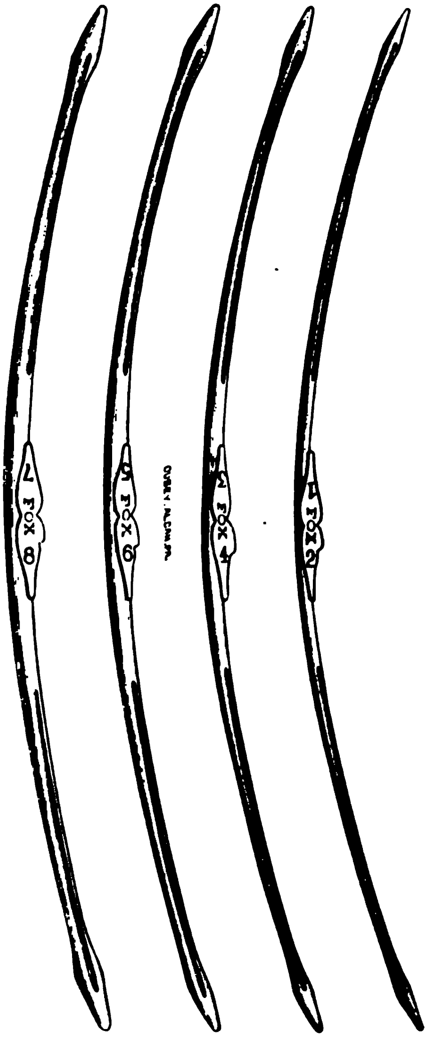

FIG. 46.—SILVER GROOVED PROBES.

The surgeon stands behind the patient, supporting the latter's head against his body, and if the operation is being performed upon the left eye, presses the thumb of the right hand over the cheek bone and just along the lower edge of the eyelid, which by this action is drawn slightly downward and outward. The bulbous point of the Weber knife is inserted into the punctum, and the handle is dropped below the horizontal plane of the eyelid. With the cutting edge of the blade inclined towards the eyeball, the knife is pushed towards the nose, and, when the point has touched the nasal bone, the handle is raised to the vertical position; the cutting edge is rotated forward and is pushed firmly, yet gently, into the canal, burying the blade well up to the handle; this is done without difficulty and without giving much pain to the patient. The knife is withdrawn and by gentle pressure the bleeding is stopped in a few minutes. A silver probe of large size, which passes well down into the canal, is now inserted, and is allowed to remain for several minutes; it is then withdrawn and a silver cannula placed in permanent position. The tube is allowed to remain in the canal for several days, when it must be removed, cleansed, and returned to its place.

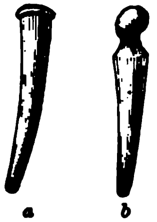

FIG. 47.—*a*, DUPUYTREN'S CANNULA; *b*, WATHEN'S CANNULA.

FIG. 48.—FOX'S GOLD CANNULA.

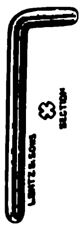

FIG. 49.—GROOVED STYLE.

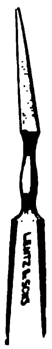

FIG. 50.—STILLING'S KNIFE.

This may be repeated at intervals of several days, until the secretions have disappeared and a free opening is obtained. When a cannula is to be worn permanently, it should be made of gold.

If pointing has occurred, Petit's method of operation should be followed—namely, incising the abscess and passing the knife into the canal below the lacrymal sac.

When we meet a patient who has had more than one operation performed, and cicatricial tissue has formed along the mouth of the sac, it is impossible to use a Weber knife. For this purpose nothing approaches a Stilling blade. The method of inserting and passing the knife downward is the same. The incision is followed by the insertion of a large-sized probe and cannula.

A very simple method of proving whether the canal is open is to have the patient shut his lips and close his nostrils with his thumb and finger, and then try to force the air through the lacrymal cannula.

The frequent raising and lowering of the tube, as described in the treatment of epiphora, is applicable here.

The introduction of lacrymal probes into the nasal duct at regular intervals is practised extensively. It is usual to either split the punctum and canaliculus or dilate the punctum by Weber's conical sound before attempting to pass the probes. One of the smaller sizes, preferably a No. 3, should be selected to start with. It is introduced in a manner similar to that of the knife in the foregoing operation, following the direction of the canaliculus. The surgeon is able to work more conveniently by standing behind the patient. The probe should be passed to the inner wall of the sac, after which it is raised so that the lower end enters the nasal duct. That the probe has followed the right channel will be indicated by the complete absence of wrinkling or

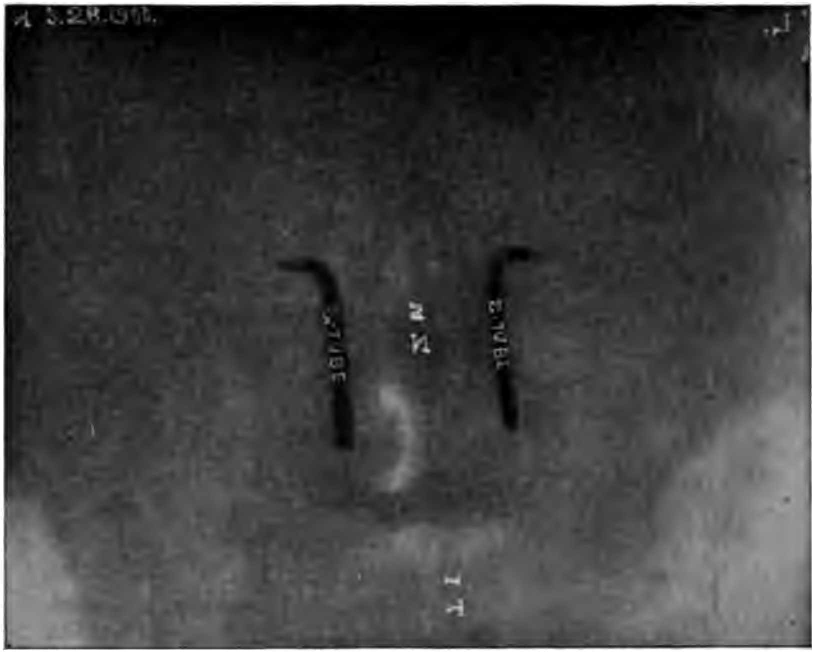

FIG. 51.—SKIAGRAPH OF TWO CANNULÆ IN NASAL DUCTS. OCCIPITO-FRONTAL VIEW, SHOWING DEVIATED SEPTUM.

creases around the probe, as there should be no traction upon the soft structure if the probe has pursued the proper course. Should the probe encounter bone-like resistance after it has been raised, the opening of the duct has been missed, and there is danger of producing false passage with more or less cellulitis if an attempt is made to force the probe farther. The inflammatory swelling offers a more yielding resistance, and is overcome by firm but gentle pressure. The probe having entered the duct, it should then be pushed onward, emerging in the inferior meatus of the nose. The probes should be allowed to remain for fifteen or twenty minutes. They are gradually increased until one of very large calibre is employed. In chronic cases it requires several days before the largest sized probe is employed. In acute cases, the sizes are increased rapidly at the first sitting until the duct is dilated to its full width, after which a leaden style is introduced.

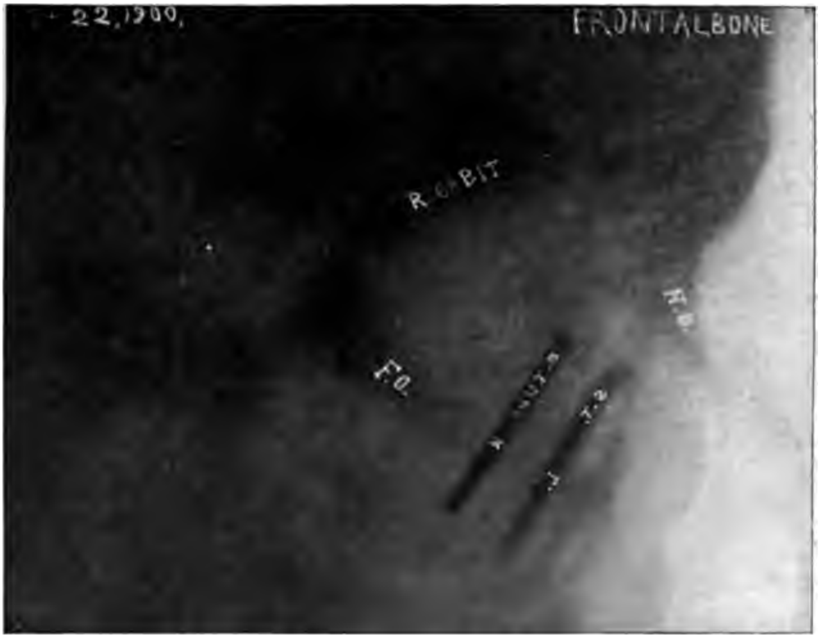

Fig 52.—Skiagraph. Silver Cannula. Lateral View.

Rapid dilatation by means of an especially constructed instrument, not unlike that of Weber's conical sound, but elbowed and mounted differently in order to afford more leverage, is in great favour among certain ophthalmic surgeons (Levis). The operation consists in dilating or slitting of the punctum and canaliculus, after which the conical probe is rapidly introduced and forcibly pushed into the nasal duct. There is always a sensation of crackling attendant upon the operation, which is attributed to carious bone; but an attempt to pass a probe of the size usually employed through the duct of a dried skull will be attended by the same phenomenon, showing that there is always some destruction of bone by the operation. The results reported from this operation in chronic lacrymal inflammation seem most gratifying

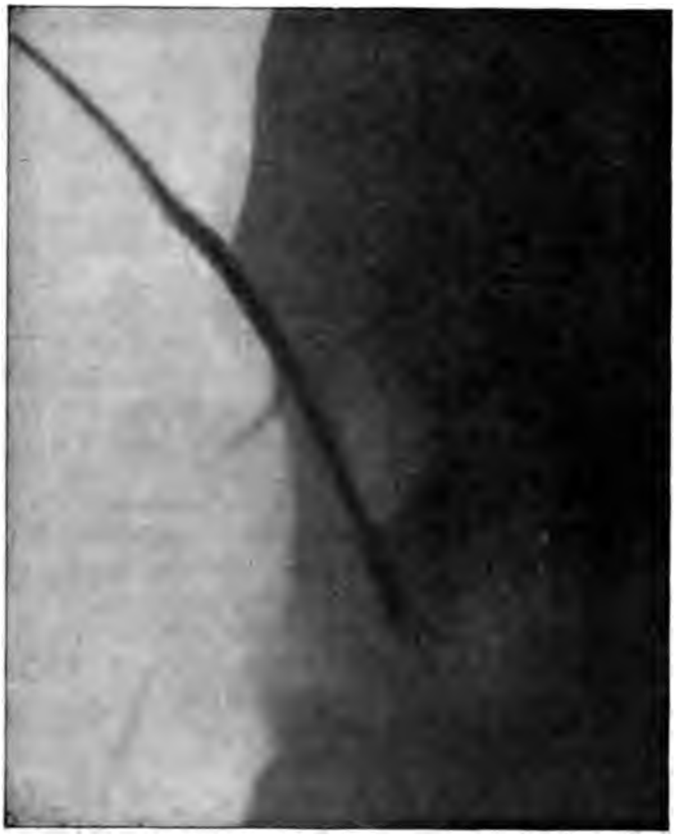

FIG. 53.—SKIAGRAPH SHOWING SILVER PROBE IN NASAL DUCT.

and deserve consideration. In acute cases the lead style is employed in addition to rapid dilatation.

Electrolysis has also been employed for the relief of strictures of the nasal duct with success. The only disadvantage of this operation is the great size of the cannula necessary for guiding the electrode, and it is questionable whether the dilating effect of this cannula is not of greater benefit than the effacement of the stricture by the electric current.

Syringing of the lacrymal sac and nasal duct after dilatation has been accomplished is a most excellent method of treatment in that it not only antisepticizes the contents, but tends to restore the mucous membrane to a healthy condition. Anel's syringe is usually employed with a cannula of a calibre sufficient to enter the punctum and canaliculus, without pain. The following solutions are used:

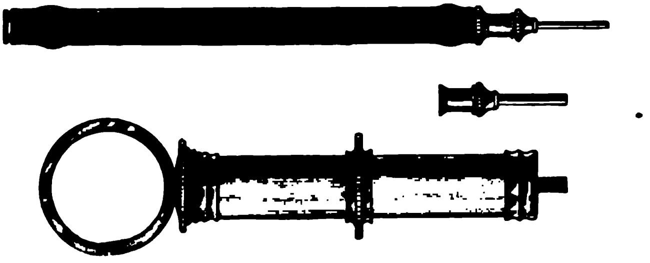

FIG. 54.—LACRYMAL SYRINGE WITH RUBBER TUBING.

Lead acetate	1	per cent.
Nitrate of silver	2 to 5	"
Zinc sulphate	0.6	"
Protargol	10	"
Tannic acid	2	"
Bichloride of mercury	0.02	"

In chronic conditions in which the secretion has accumulated in the lacrymal sac, constituting mucocele, it has been advised to express the contents by pressure and gentle manipulation. While this is a harmless procedure, it cannot be relied upon, and should not be preferred to more effective methods of treatment in view of the character of the sac contents.

In cases of abscess formation, and even in obstinate chronic dacryocystitis, some surgeons prefer to incise the anterior wall of the sac, curetting the interior and packing it with gauze. When the mucous membrane has regained its normal condition the packing is removed, and the external wound allowed to close.

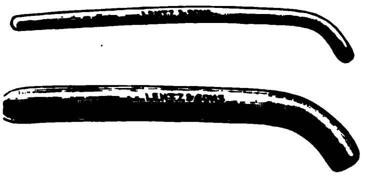
FIG. 55.—WAMSLEY'S STYLES.

Extirpation of the sac is recommended as a last resort, but the difficulty encountered in performing this operation usually causes it to be changed into one of destruction by the use of caustic and the cautery.

Prognosis.—Disease of the lacrymal passage, if untreated, is always a source of danger to other portions of the eye. The infectious and virulent character of the secretions within the lacrymal sac in these conditions induces blepharitis, conjunctivitis, keratitis, ulcers serpens, etc. Their greatest danger lies in the ease with which they are overlooked. Operations, such as cataract extraction, that end in suppuration of the eye, can frequently be traced to such conditions. The application of the treatment described will all lessen this danger by the free drainage they afford. The epiphora may remain. The chronic form is most obstinate, the acute form resulting in free drainage by fistula formation, if untreated. In my experience, the best results have been obtained by the operation described first.

For cases in which the ordinary methods, such as the passage of graduated probes and the introduction of cannulas in the nasal duct, have failed to bring about a favourable result, Wamsley, of Philadelphia, has devised a form of treatment for which he claims most excellent results. After having split the canaliculus for its entire length he introduces a short aluminium probe, as shown in the accompanying illustration. These probes are of three lengths, 35 millimetres, 40 millimetres, and 45 millimetres. The probe should be passed to the floor of the nose so as to dilate the entire length of the duct. After a few days the probe is withdrawn and replaced by one of greater diameter, and this is repeated until a probe of No. 7 English Standard wire-gauge is introduced. This very large probe is worn

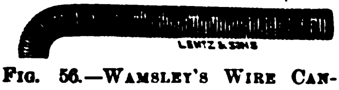
FIG. 56.—WAMSLEY'S WIRE CANNULA.

until reaction subsides, after which a coiled wire tube is introduced. This tube is made of fine 14-karat gold wire, No. 29 gauge B. and S. The wire is closely coiled upon a metal rod of the thickness No. 9 English Standard wire-gauge. It is then annealed, so that its shape will be retained. After the gold tube thus made is taken from the rod it is placed upon another wire, turned to a half circle at one end. It is again annealed in order to hold the slight curve thus given to it.

In order to insert this coiled wire tube an introducer is necessary. This instrument should be passed into the duct down to the floor of the nose after the aluminium probe is withdrawn.

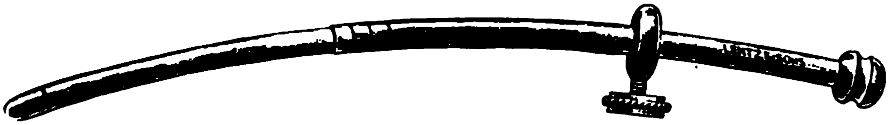

FIG. 57.—WAMSLEY'S INTRODUCER.

The cannula or the introducer is slid down until its first ring engages just below the margin of the canaliculus lips. The cannula is fixed in this position by the screw on the end outside of the duct. The introducer is withdrawn and the length of the duct is obtained by measuring from the end of the cannula to the ring at the end of the instrument. The coiled wire is then placed over the introducer, the curved portion being passed over first. The ring on the end of the introducer indicates the point at which the excess of the tube should be cut off. The introducer is then passed into the nasal duct and the rod withdrawn, the cannula serving to prevent the withdrawal of the wire tubing. Wamsley claims that the wide calibre of the tube prevents its becoming filled with mucus, etc., and the spring of the wire allows perfect adaptation of the tube to the duct.

CHAPTER V

DISEASES OF THE CONJUNCTIVA

The most important affections to which the conjunctiva is liable are inflammatory in character, and are preceded by a condition of hyperæmia or overfilling of the blood-vessels. This conjunctival hyperæmia is not restricted to the inflammatory affections, but is common to all conditions which in any way irritate that membrane, such as foreign bodies, growths, etc. It is often spoken of as conjunctival injection, and should be distinguished from ciliary injection, which indicates more serious conditions. The conjunctival injection is derived from the posterior conjunctival vessels, is most marked in the fornix, fades as the cornea is approached, is bright red in colour, is superficial, and can be moved by pressure upon the lid.

Ciliary injection, on the other hand, takes its origin from the anterior ciliary vessels, is most marked directly around the cornea, fading towards the periphery of the globe, is pink or lilac in colour, and cannot be moved by displacing the conjunctiva on account of its deep situation. It accompanies disease of the cornea, iris, and ciliary body. Ciliary injection of a pronounced violet colour is always venous in origin, and is most marked in scleritis and glaucoma.

In extremely severe ocular inflammations these forms of hyperæmia may coexist.

Œdema of the conjunctiva is often associated with inflammation of that structure, and is termed *chemosis*. The lymphatic spaces may enlarge, resembling transparent beads or small cysts.

Not uncommonly the conjunctiva presents abnormalities in colour that are departures from normal. One of the most common is the deposition of bile pigment or jaundice which accompanies hepatic disorders. It is usually transitory, and while it may occasion itching and burning of the eyes, it induces no serious result. Silver nitrate, when employed over a long period, is followed by oxidation of the deposited particles with the production of various slate-coloured tints on the conjunctiva. This discoloration is permanent, and is known as argyrosis. Staining by the blood pigment may follow burns, injury, coughing, straining, etc., and is not permanent. In gouty individuals the deposition of particles of urates in the conjunctiva render it opaque in spots. This condition is most frequent on the palpebral conjunctiva, and is accompanied by the sensation of a foreign body.

PALPEBRAL CONJUNCTIVITIS

SYNONYMS: *Hyperæmia of the conjunctiva; Simple catarrhal conjunctivitis.*

Definition.—A condition characterized by hyperæmia of the conjunctival blood-vessels, enlargement of the follicles of the conjunctiva, particularly in the palpebral region, and slight general congestion of the eyelids and eyeballs. There is usually a slight excess of secretion.

It is the mildest form of disease affecting the conjunctiva, the condition being due simply to a marked excess of blood in that structure. The hyperæmia may be either active or passive, the former by reason of an increased flow of blood to the conjunctiva, and the latter on account of an obstructed outflow of blood; it may also be either acute or chronic.

Causes.—Long-continued near work and strain of the ocular muscles; uncorrected errors of refraction; local irritants, such as cold, chemicals, dust, wood or tobacco smoke; abuse of alcohol, and associated diseases, such as nasal catarrh; lacrymal obstruction, and marginal blepharitis of an acute form which attends the infectious fevers.

Symptoms.—The symptoms are slight congestion, swelling of the conjunctival follicles, photophobia, and increased lacrymation. Exposure of the eyes to strong illumination, or attempts to read, soon fatigues them. The patient complains of a gritty sensation—as if sand were in his eyes—smarting, and itching. A thorough examination of the folds of the conjunctiva is always necessary, since foreign bodies lodged in the *cul-de-sac* produce similar subjective symptoms.

Treatment.—In all conjunctival affections where there is a nasal catarrh, lacrymal obstruction, etc., these conditions must be first treated. If any optical defects are detected, they should be corrected by prescribing proper glasses, and if the patient already wears glasses, their fitness for his eyes should be ascertained.

If the hyperæmia is active, cold applications are indicated; if passive, hot fomentations should be tried. The use of poultices in any affection of the eye is to be emphatically condemned. If overwork and anæmia are factors in the ætiology they should receive attention.

In chronic cases a weak silver-nitrate solution (½ grain to 1 ounce) should be used several times a week, being applied by means of a cotton swab, and followed by spraying the everted lids with Formulas 6 and 9. A few drops of a very weak solution of zinc chloride may be instilled in the eye at night in very severe cases.

The prescriptions which the author has found useful in the various forms of conjunctivitis have been given in the Appendix (*q. v.*).

Prognosis.—If the conjunctivitis is acute it will yield to treatment in a few days, at the most in a few weeks. On the other hand, if it is chronic in nature, the disease may fail to yield to treatment for months, or even years.

MUCO-PURULENT CONJUNCTIVITIS

SYNONYMS: *Simple conjunctivitis; Conjunctivitis; Simple ophthalmia; Catarrhal ophthalmia; Follicular catarrh; Conjunctivitis papillaris.*

Definition.—A condition characterized by inflammation of the conjunctiva, and accompanied by a discharge which is usually muco-purulent in character. It may be acute or chronic.

The disease is almost always bilateral, and while it occurs in persons of all ages it is more frequently seen in young individuals. The cases are more numerous in spring and autumn than at any other time of the year.

Causes.—The causes include all those already mentioned under Palpebral Conjunctivitis. The chief cause, undoubtedly, is contagion, the active agents being the ordinary pus cocci.

Chronic palpebral conjunctivitis may also develop into this variety.

Since the contagiousness of this disease has been established beyond dispute, it is the duty of the attending physician to urge upon his patients, and those with whom they come in contact, the absolute necessity of observing scrupulous cleanliness and the exclusive use of separate towels, handkerchiefs, wearing apparel, etc.

Symptoms.—The palpebral folds of the conjunctiva are hyperæmic, and the capillaries, especially the larger ones, injected. The eyelids are adherent to each other in the morning, from the solidification of the discharge, which in the first stages of the disease is scanty. As the disease progresses, the discharge increases in quantity, and may be as copious as in purulent conjunctivitis. Eversion of the lower eyelid reveals small masses of the discharge in the lower *cul-de-sac* of the conjunctiva. Small ecchymotic areas are frequently present in the conjunctiva.

Pain is most marked in the early stages of the disease, and may vary from a mere feeling of discomfort to the most severe burning or itching, depending on the severity of the attack. The sensation of a foreign body, such as sand or dust, in the eye, is often complained of by the patient in the earliest stage of the disease.

The discharge consists of an increased quantity of the normal secretion and cast-off epithelial cells, with a variable proportion of pus and micro-organisms. If the discharge of pus is scanty, as is often the case, it is whitish in colour and threadlike in appearance; as the proportion of pus increases, it becomes more and more purulent in character. Its consistency of course depends upon the extent to which it is diluted by the secretion of lacrymal fluid.

Diagnosis.—Muco-purulent conjunctivitis passes by insensible gradations into purulent conjunctivitis, from which, on the one hand, as well as from the palpebral form on the other, it appears to be distinguished chiefly, perhaps solely, by the degree of its severity.

Treatment.—The eyes should be frequently bathed, so as to insure absolute cleanliness. Free instillations of a solution of boric acid and borax or sodium chloride (Formulas 6 and 8), at intervals of one to four hours, depending upon the severity of the disease, should be prescribed.

If there is suppurative inflammation of the lacrymal apparatus, dioxide of hydrogen with equal parts of Dobell's solution may be used in a lacrymal syringe to cleanse this passage.

When the case is seen early, and appears severe, its course may be shortened by one or more applications of a solution of silver nitrate (5–10 grains to an ounce) or protargol (20 per cent).

The patient's general condition must be carefully looked after; and if he is poor in health tonic remedies are indicated and should be prescribed.

Prognosis.—In the milder types of this disease it is self-limited, running its course in from two to three weeks. If no treatment is instituted, a longer time will be required for recovery to take place; chronic cases are not, however, by any means rare occurrences. If treatment is begun early, the conjunctivitis may be aborted; as a rule, cure may be effected without great difficulty at any particular stage in the acute form.

PURULENT CONJUNCTIVITIS

Synonyms: *Purulent ophthalmia; Conjunctival blennorrhœa; Contagious, military, or Egyptian ophthalmia; Ophthalmia neonatorum; Diphtheritic and gonorrhœal ophthalmia.*

Definition.—A specific conjunctival inflammation with purulent discharge, nearly always due to infection by gonococci.

The various forms of purulent conjunctivitis are distinguished from muco-purulent conjunctivitis by their greater severity, and by the fact that they are much more highly infectious.

A variety of this disease has been observed in patients suffering with gonorrhœa, in whom direct infection of the eye has been excluded; in such cases the disease is less severe.

Symptoms.—Within a period varying from a few hours to several days after the infection—depending upon the virulence of the micro-organisms—the eye presents the symptoms of muco-purulent conjunctivitis. The inflammation increases in severity, there is excessive swelling of the lids, and copious discharge. The lids are very sensitive to pressure, and in the earlier stages of the disease they are tense, and very often smooth and shiny; in the later stages they become softened. The lids are so swollen that the patient is unable to open them, and the physician may have considerable difficulty in obtaining a view of the cornea.

The discharge, which at first is clear and watery, may contain shreds and flakes of mucus and may even be discoloured. It becomes more purulent within twenty-four or forty-eight hours, until it presents a typical appearance—a creamy, slightly greenish pus.

Two varieties of purulent ophthalmitis are distinguished:

1. Ophthalmia neonatorum.
2. Gonorrhœal ophthalmia.

Ophthalmia neonatorum is the term applied to the purulent conjunctivitis in the new-born, which is due to the infection of the baby's eyes during birth by the purulent discharge from the vaginal canal or uterine cervix of a mother who is suffering with leucorrhœa or gonorrhœa. This is a serious condition, and is remarkable in that it causes more blindness than any other single cause. (Statistics show that in the United States 30 per cent of the blind have lost their sight as the result of ophthalmia neonatorum and its sequels.)

Diagnosis.—The violence of the symptoms of conjunctival inflammation, the rapid progress and extent of the swelling, and the free watery and flocculent discharge are the first points that lead to a suspicion of purulent conjunctivitis. If shortly after a child is born (twenty-four hours) a slight discharge makes its appearance, the probability is that we have to deal with ophthalmia neonatorum, and it should be at once treated accordingly. Microscopic examination of discharge will aid very greatly in distinguishing it from less virulent affections.

Treatment.—Infection occurs during delivery, although, in rare cases, children are born with the inflammation already developed, having probably been infected shortly after an early rupture of the membranes in a slow labour. A few cases become infected subsequently to labour from lack of proper cleanliness.

The treatment is based on the same principles which apply in the treatment of gonorrhœal ophthalmia, allowance, of course, being made for the difference in the patients' ages and constitutions.

The child's head should be placed between the knees of the physician, the rest of the body of the child being held by the nurse; the upper lid is raised by means of a retractor, when the swelling is not too great, and thoroughly cleansed and irrigated every hour, until the discharge has diminished or has altogether ceased.

Once a day the lids should be everted, the child being held in the same position, and an application of nitrate of silver (5 grains to the ounce) made; this should be followed in one hour by a lotion (Formula 23) which is in great favour in the treatment of all purulent discharges of the eyelids.

Adrenalin (1 to 3,000) may also be applied four times daily to assist in contracting the blood-vessels, and will tend to prevent the liberation of serum, and thereby lessen the pus products.

Iced pledgets of cotton must be applied, wrung out in 1 to 2,000 or weaker bichloride-of-mercury solution, but they need not be changed as often as in the more active forms of this disease. For the method of preparing cold dressings, see Treatment of Gonorrhœal Ophthalmia. They should always be used in addition to the nitrate-of-silver treatment or protargol 20-per-cent solution.

Prophylaxis.—It should always be ascertained whether or not the mother has had a discharge from the vagina, either mild or profuse, before the birth of the child. If a discharge has existed, it should act as a stimulus to greater watchfulness on the part of the attending physician, and every energy should be bent towards preventing development of the ocular disease in the infant. The eyes of the child are, as a rule, infected while passing through the birth canal, but the development of the disease can usually be prevented if proper measures are applied. The eyes of every child should be immediately cleansed after birth, and a 2-per-cent solution of silver nitrate freely instilled. This prophylactic measure is due to Credé; if it were adopted as universally as it deserves to be, the disease could generally be prevented.

The disease is generally bilateral; if, however, one eye only is affected at the time the case comes under observation, the healthy eye should be protected by a Buller's shield, or a light compress of cotton securely fastened.

Gonorrhœal ophthalmia is the term given to the form of conjunctivitis caused by infection of the urethra, the infective material being carried directly to the eye by the hand, towel, handkerchief, etc.

Diagnosis.—Besides the characteristic subjective symptoms, adults generally give a history of antecedent urethral or vaginal discharge, due to gonococcus infection, which in itself is sufficient evidence to lead one to consider the case as purulent conjunctivitis. The character of the pus is an important aid in diagnosis, and a careful microscopical examination of the discharge will almost invariably clear up a doubtful case.

Treatment.—The first and most important consideration is cleansing the eye of all discharges. The lids should be everted and the discharge removed every one or two hours by means of a bit of soft, moistened lint or the hydrostatic eye douche. The conjunctival sac should be irrigated with an antiseptic solution, such as corrosive sublimate (1 to 2,000), which may be iced, or permanganate of potash (1 to 1,000), making the applications every half hour during the first twenty-four hours, at the end of which time, if the discharge is lessened, the strength of solution is reduced and the intervals of application increased. The solution is gradually weakened to 1 to 5,000, in which strength it is continued as long as pus is found in the conjunctival sac.

FIG. 58.—IRRIGATING BOTTLE.

The prescription for an astringent, antiseptic lotion used by the author is given in the Appendix. (Formulas 22, 23, 24, 32.)

The application of cold by means of pledgets of lint or cotton is not only beneficial in allaying the pain, but also serves to reduce the swelling. These cotton dabs are applied continuously, day and night, until a diminution of the discharge is noted. A bowl of cracked ice is prepared, and into this a smaller bowl is set. The lotion to be used is poured into this smaller bowl and dabs of lint or cotton are soaked in it—a dozen or more at a time. They are taken as required and applied to each closed eyelid for from five to eight minutes. They are then thrown away and replaced by fresh pledgets taken from the bowl. At intervals of an hour a few drops of a 20-per-cent solution of protargol are applied to the conjunctival sac. During the last few years I have also applied eserine (½ grain to 3 drachms) with very good results (Formula 25) in cases in which the cornea became steamy in appearance. If, in spite of this treatment, the cornea breaks down, a 5-per-cent solution of trichloracetic acid is applied directly to the ulcer once every twenty-four hours. The most strenuous efforts should be made to prevent blindness, and the physician and nurse should be untiring in their endeavours to make the best possible use of the various remedies at their command.

Hot applications should be substituted when haziness of the cornea shows that its nutrition is being impeded; cold applications should not be used at all in weak and anæmic patients.

The pain may also be relieved by subcutaneous injections of morphine in the temple, or the internal administration of opium, or some of the coal-tar products, as sulphonal, trional, etc.

The inflammation and œdema may be reduced by applying leeches to the temple, cold compresses over the eyes and neighbouring tissues, or by incisions of the lids at the outer canthus, to relieve the pressure on the eyeballs.

After the early stages of the disease have passed, when there is free creamy secretion, and the lids have relaxed their tension, the palpebral conjunctiva should be touched once daily with a mitigated solid silver stick, or a solution of nitrate of silver (20 grains to the ounce). When the discharge has ceased, an alum or copper sulphate pencil may be employed in the same manner.

If silver-nitrate solution is used, the eye must be washed immediately afterward with warm water, or the silver nitrate may be neutralized by a weak solution (½ per cent) of sodium chloride.

The cornea should be subjected to the most careful and frequent observation. If cloudiness of that tissue increases, and the caustic fail to effect improvement, they should at once be discontinued, and protargol (20-per-cent solution) should be employed, supplemented every hour by applications of Formula 25. The ointment of boroglycerin should be used once or twice daily for the purpose of anointing the eyelids. Granular formations similar to trachoma commonly appear on the innner surfaces of the lids when the chemosis and discharge have decreased or ceased altogether. The internal administration of large doses of calomel and the use of mercurial inunctions are especially indicated when there is a tendency to plasticity.

Prophylaxis.—Physicians treating patients suffering with gonorrhœa cannot warn them too strenuously against the danger to the eye if absolute cleanliness is not observed. In adults usually one eye only is affected at the beginning of the disease, and the greatest care should be exercised to prevent the virus or infective material passing from the diseased eye to the healthy eye. As soon as one eye appears to be infected, it is advisable to close the other with an impervious dressing. Linen should be placed upon the lids, and over this absorbent cotton, which should be painted down with collodion, especially at the nasal margin, where the infective material finds freest access. A Buller's shield consists of a watch-glass stitched into rubber cloth fastened at the margin by strips of adhesive plaster, and is highly recommended in these cases.

A very peculiar case of infection came recently under the author's observation at the Medico-Chirurgical Hospital. The man had an attack of gonorrhœa, and while handling an artificial eye which he was wearing, infected the conjunctival sac. A most violent attack of gonorrhœal ophthalmia developed. To prevent infection to his only eye a Buller's shield was placed over it; by this means the infection confined itself to the socket of the enucleated eye.

Prognosis and Sequelæ of Purulent Conjunctivitis.—Skilful treatment will save the eye in almost all cases of ophthalmia neonatorum, and in a large proportion of the violent cases of gonorrhœal ophthalmia, provided it is instituted early enough.

Corneal ulcer and perforation are the tragical results that are to be feared if the case does not come under treatment early in its course, or if the treatment is unsuccessful. Corneal perforation may result in prolapse of the iris, anterior synechia, anterior staphyloma, and probably hopeless blindness.

The process of involvement of the cornea is not well understood, but it is, in all probability, due to direct infection by the virulent discharge. This infection is rendered easier by the obstruction offered to the nutrition of the cornea. The pressure of the swollen lids on the cornea interferes with the normal anastomoses, and the nourishment of the cornea may be so badly impaired that necrosis takes place.

When the cornea becomes involved, a small ulcer usually develops near the lower and outer corneal margin, which extends rapidly both in area and in depth; or a considerable portion of the cornea—usually at the centre—becomes opaque and breaks down, leaving a large, rapidly progressive ulcer, which is very apt to cause perforation and bring about a serious termination.

PHLYCTENULAR CONJUNCTIVITIS

SYNONYMS: *Scrofulous, strumous, or pustular conjunctivitis; Phlyctenulo kerato-conjunctivitis; Conjunctivitis lymphatica; Conjunctivitis eczematosa.*

Definition.—Inflammation of the ocular conjunctiva, characterized by phlyctenulæ at the corneal margin, and sometimes by a congested vascular network extending towards the cornea.

The cornea is generally implicated to a certain extent, and the disease is dangerous in proportion to this implication.

Causes.—The disease depends on a scrofulous diathesis; it occurs in children (commonly young girls about the age of puberty), with an underlying tendency to catarrhal affections of all mucous surfaces, eczematous eruptions, and glandular enlargements. The exciting cause is undoubtedly some micro-organism. While it may occur in adults, it is much commoner in children, constituting about 25 per cent of all diseases of the eye in children. When it is met with in adults there is always a history of eye trouble in childhood.

The affection frequently makes its appearance as a sequel to one of the infectious fevers, and nearly always occurs in debilitated subjects. It is most often encountered in the children of the poor, in whom nutrition is low and whose surroundings are positively unhygienic. The dietary of these children is made up largely of tea, coffee, and similar unwholesome articles which contribute to the ætiology by the nutritional disturbances they induce. It may occur in the children of the better classes, in whom these causes are apparently absent, but careful inquiry and examination will serve to disclose some underlying predisposition such as already described.

Symptoms.—The disease usually begins with irritability of the eyes, photophobia, and excessive lacrymation. Vesicular elevations make their appearance on the ocular conjunctiva, usually near the corneal margin, or on the cornea itself. The phlyctenulæ are quickly transformed into small ulcers, from which a pus-like exudate, containing epithelial cells and bacteria, escapes. The conjunctiva is intensely red, which redness appears at first in spots, later tending to become general. This redness disappears in a few days, the swollen tissue of the phlyctenulæ gradually returning to normal. The entire attack lasts from one to four or five weeks, unless prolonged by corneal ulcer. Quite often a second attack begins before the first has terminated, so that the eye is continually in a red and painful state.

The palpebral conjunctiva appears hyperæmic, the vessels being larger than normal, and there may be a slight discharge, causing the lids to be glued together in the morning.

An extension of the disease to the cornea is characterized by the appearance of one or more of these nodules advancing from the margin to the centre, accompanied by a red band or fascicle of blood-vessels. This gives rise to a superficial form of corneal ulceration known as fascicular keratitis. In severe cases, corneal infiltration may be induced.

The photophobia is often very severe, in fact so severe that the patient refuses to open his eyes even when placed in a darkened room.

Diagnosis.—The distribution of the hyperæmia, the occurrence of the phlyctenulæ, or the ulcers that follow them, the excessive photophobia and lacrymation, and the discharge, are symptoms which differentiate this form from acute catarrhal conjunctivitis.

Treatment.—The treatment is general and local. Although the severity of the ocular symptoms would indicate local treatment alone, the constitutional disturbances should receive first consideration. Tea, coffee, fried foods, sweetmeats, cakes, candies, etc., should positively be withheld. Fresh air, daily bathing, milk in abundance, sunlight, cleanliness, etc., should be prescribed. Calomel (gr. $\frac{1}{20}$) should be administered twice daily for its antiseptic effect upon the intestinal tract. Cod-liver oil should also be given internally, but is preferable when not emulsified. The syrup of the iodide of iron, quinine, and arsenic are also indicated. The accompanying nasal, aural, or dermal conditions should also be promptly treated.

Locally the eye should be placed at rest by the wearing of a protective bandage or dark glasses. Irrigation of the conjunctiva should be performed frequently with the ordinary boric-acid solution (gr. x to the ounce). The employment of medicaments in ointments is of especial value in this connection. (See Formulas 27, 28). Atropine is usually employed, but a persistence of the intense photophobia indicates eserine. Calomel should be dusted upon the ulcers except when iodine is being administered internally. Cold compresses relieve the attendant pain, but should be substituted by hot compresses if there is any indication of corneal involvement.

The photophobia is often so intense that marked blepharospasm is induced which interferes greatly with the treatment. In such cases, dipping of the child's face forcibly into a basin of cold water and holding the head immersed until the lids open serves to overcome this spasm of the orbicularis muscle (Arlt). Sometimes it is so intense as to require temporary canthoplasty.

The author's best results in breaking up the intense orbicularis spasm are obtained by stretching the eyelids to their utmost by the aid of lid retractors. The stretching should last from three to five minutes. This, of course, must be performed under an anæsthetic. The instillation of cocaine often relieves the condition by lessening the sensitiveness of the conjunctiva and cornea. The ulcerations will be greatly benefited by the application of some form of silver. Protargol, strong solution of silver nitrate, or the solid silver nitrate stick may be employed. A decoction of poppy-heads applied to the eyelids serves to relieve any attendant pain. A combination of suprarenal extract (1 to 1,000) and chloretone has given gratifying results in this affection by reason of its hæmostatic, anæsthetic, and antiseptic properties.

The prognosis is favourable in most cases. Usually it undergoes involution in one to five weeks, but recurrences are frequent. Slight opacities may remain if the cornea is involved. In severe cases, perforations and its sequelæ may occur.

DIPHTHERITIC CONJUNCTIVITIS

Diphtheritic conjunctivitis is a very rare disease, being more common in Europe than in this country. It is almost exclusively confined to children, although occasionally cases of the disease in adults have been reported.

If, on everting the lids in an incipient case of conjunctivitis, small areas of a pale gray colour, infiltrated with rigid material that strongly resists the eversion of the lids, are found, and infiltration of the conjunctiva is also observed, diphtheria of the conjunctiva should at once be suspected.

Symptoms.—The lids are tense, on account of the rapid and great swelling, very hot, and exquisitely tender to the touch. The board-like stiffness of the lids may be so marked that they can scarcely be opened, and may be everted only under anæsthesia. There is generally high fever. In purulent ophthalmia we have seen that although the eyelids may be greatly swollen, they are soft, flaccid, and are not painful to the touch, nor is the temperature very high. The lids may also be readily everted.

The paler areas of the conjunctiva mark the greatest infiltration and diminution of the blood supply. The discharges on the surface of the conjunctiva often assumes the form of thin, yellowish, reticulated patches of varying size. In some instances, thick opaque membranes are formed which are so coherent that they can be stripped off with difficulty in large pieces from the inner surface of the lids. The forcible removal of this structure may, however, cause considerable bleeding. The conjunctiva thus denuded does not present a red, succulent, villous surface like that seen in purulent ophthalmia, but instead, another layer of this yellowish substance.

The course of the disease may be very mild, and therefore not very dangerous, if it occurs secondarily to diphtheria, but, on the other hand, it may occur as a primary affection and run a more serious course. It may also be secondary to purulent ophthalmia, the latter assuming a diphtheritic character.

The cornea is quite apt to be affected early in the course of the disease, in which case it breaks down rapidly and is partially or totally destroyed. When the cornea becomes implicated, its lustre is diminished to a certain degree, its surface faintly clouded, and the epithelial layer somewhat abraded. The dense, hard, infiltrated conjunctiva pressing upon the cornea and upon the blood-vessels supplying it, greatly impairs its nutrition, and necrosis of this structure may very shortly ensue. The sloughing of the lids is very apt to cause adhesions between them and the eyeball, producing the condition known as symblepharon, which will presently be described.

Cases have been reported in which there was very little infiltration of the eyelids, the symptoms, in the main, being those of catarrhal conjunctivitis with a slight sanious discharge.

Diagnosis.—The extreme rigidity of the lids, with the same amount of swelling as in other diseases of the lids, and the gray patches of strangulated tissue which may coalesce and extend over the entire conjunctival surface as far as the corneal margin, are characteristic points of this disease. In *croupous conjunctivitis* the membrane is superficial, somewhat resembling the diphtheritic membrane found in pharyngeal diphtheria, while in conjunctival diphtheria there may be no membrane upon the surface, or it may be a less conspicuous symptom than the rigidity of the deeper tissues. The exudation is in the conjunctiva and not on it. If upon examination of the products under the microscope the Klebs-Löffler bacillus is found the diagnosis is certain.

Treatment.—It is of the utmost importance that the disease be promptly recognised, and treated by full injections of diphtheria antitoxine, repeated at intervals of not more than sixteen hours (Standish). The results obtained from this mode of treatment have been very satisfactory. If there is great swelling of the lids, the patches of gray, rigid infiltration small and few, and the cornea has not become involved, pledgets of cotton soaked in a 1 to 1,000 permanganate-of-potassium solution should be applied locally. If the patient is in a depressed condition, and the cornea shows signs of infiltration, cold applications are to be avoided, and hot applications substituted. According to some authorities, cold should never be applied in this disease, as involvement of the cornea is almost certain to take place. Eserine may be used in the attempt to prevent corneal complication; some authorities prefer atropine for the same purpose. Formula 25 is valuable applied either cold or warm.

Careful cleansing of the conjunctiva with an antiseptic wash (permanganate of potassium, 1 to 1,000) is very important and should never be neglected. In the second stage of the disease, when the secretion is free and the lids have lost their rigidity, the permanganate solution should again be used, applying it to the under surface of the lids. This solution must be employed as long as any trace of the diphtheritic membrane remains. Mr. Tweedy, of Moorfield's, recommends the use of bisulphide-of-quinine solution. A saturated solution of pyoktanin (blue) has been applied with success in this disease. The local application of the silver preparations has also been employed.

If only one eye is affected, the healthy eye should be very carefully protected against infection, as in purulent ophthalmia.

The patient's strength should be supported throughout the attack by strychnine, alcohol, and iron.

Prognosis.—The chance of saving the eye depends solely upon the early institution of the antitoxine treatment, and the local applications of such lotions as are designated in the text; if it is not begun early in the course of the disease, sloughing of the cornea will certainly take place and result in blindness.

CROUPOUS CONJUNCTIVITIS

Synonyms: *Plastic conjunctivitis; Croupous ophthalmia.*

Croupous conjunctivitis appears to be essentially nothing more than a catarrh of great severity in which the intensity of the inflammation has led to the production of a false membrane. It occurs in childhood, but has no connection with laryngeal croup.

Symptoms.—The initial symptoms are those of violent catarrhal ophthalmia. The lids are œdematous, there is swelling of the conjunctivæ, and an abundant muco-purulent discharge. A few days after the onset of the disease, the palpebral portion of the conjunctiva is found covered in patches, or sometimes in its entire extent, by a whitish-gray membrane, much resembling that observed in diphtheritic conjunctivitis, although it is more superficial. If this membrane be torn away the exposed surface bleeds very freely. After a time the membrane separates spontaneously, leaving the surface of the conjunctiva in much the same condition as in the later stages of severe catarrhal inflammation. It may occur as the result of micro-organism infection or as the reaction to thermal or chemical irritants.

Treatment.—This condition does not respond readily to treatment, and no energetic measures should be taken as long as the croupous membrane is present. Iced compresses on the eyelids, as well as leeches applied to the temple, are of great service. Removal of the membrane does not appear to be of any value, and as it induces bleeding, it is better to leave it undisturbed. Caustics should not be applied until the false membrane has disappeared. If for any reason the membrane is removed, it should not be torn off roughly, as small hæmorrhages that are rather difficult to control are very apt to result. The eye should be freely washed with a mild antiseptic lotion (Formula 7). After irrigation a few drops of a 25-per-cent solution of boroglyceride should be dropped into the eye. Enzymol (50-per-cent solution) has given good results in the hands of Dr. T. Chalmers Fulton.

Protargol, in a 20-per-cent solution, was used most successfully by the author in one of his cases, the membrane disappearing after the second day.

Mercury, administered internally, is of great service, and the ointment should be applied locally to the temples. General stimulation has been found very beneficial, and should be resorted to in all forms of conjunctivitis.

Prognosis.—The prognosis is favourable. The deposit is usually limited to the surface of the lids, and the cornea very rarely becomes involved. Rigorous prophylaxis should be observed when the affection is monocular, and in this connection Buller's shield is extremely useful.

VERNAL CONJUNCTIVITIS

SYNONYMS: *Spring catarrh; Frühjahr's catarrh; Summer catarrh (Sommer); Saemisch's disease; Phlyctæna pallida; Hypertrophie perikeratique; Conjunctivitis verrucosa; Sommer (summer) conjunctivitis.*

This is a somewhat infrequent affection of the conjunctiva, except at certain seasons of the year, and is rather difficult to properly name and classify, as it differs from any other known form of conjunctivitis. It may be considered as phlyctenoid conjunctivitis. It is much more frequent in young individuals, and affects chiefly the male sex. The disease usually affects both eyes, but its particular characteristic is its chronic course; the disease recurs every spring and summer for a variable number of years.

Symptoms.—The disease, which makes its appearance with the first warm days of spring, is characterized by excessive itching. The conjunctiva, which is slightly swollen, has a bluish-pink tint, and that of the tarsus is covered with broad, flattened papillæ, while brownish, uneven, hard nodules of gelatinous appearance grow upon the bulbar conjunctiva from the limbus of the inner and outer side of the cornea. These changes in the bulbar conjunctiva are not so constantly present as those in the tarsal conjunctiva. No pain is experienced, although the itching is intolerable, and photophobia causes the patient a considerable amount of distress.

Unless carefully observed, vernal conjunctivitis may easily be confounded with the catarrhal variety, since the palpebral conjunctiva presents in the recurring stage symptoms of catarrhal conjunctivitis with slight mucous secretion. As the disease develops, the conjunctiva in the retrotarsal fold becomes grayish red, and has a flaky appearance, even after the secretions have disappeared. In some cases a mushroom-like protuberance spreads over the ocular conjunctiva, particularly on the temporal and nasal sides of the cornea.

The excessive itching of the eyeball is the most characteristic symptom, and lasts for weeks. The effort to gain relief by constant rubbing increases the injection, the swollen conjunctiva assuming a bluish-pink tint around the cornea, and it is with difficulty that the eyelids can be kept open. This condition lasts as long as the warm weather continues, but, like hay fever, rapidly disappears when there is a drop in the temperature to about 65°. The author recalls a patient who obtained instant relief by going into a cold-storage warehouse; however, this relief only lasted while under the influence of the cold atmosphere. Patients with hay fever obtain the same temporary benefit. It is astonishing to note the disappearance of the symptoms during a period of cool weather. The objective findings in this disease are much the same in winter as in summer, but the subjective symptoms entirely disappear.

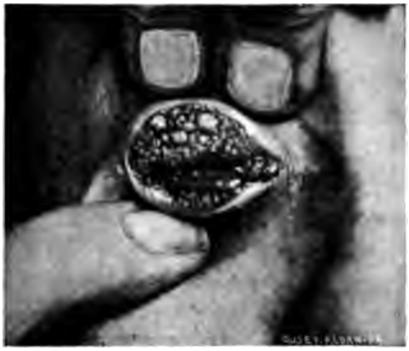

FIG. 59.—VERNAL CONJUNCTIVITIS.

Treatment.—No plan of medical treatment, either general or local, that can be relied on to cure the affection, has as yet been devised. The internal administration of Fowler's solution of the arsenite of potash, 5 drops three times daily in water, has been highly recommended. Local applications of astringents sometimes diminish the discomfort. Formula 55 seems to relieve the itching, and gives a sense of comfort to the patient as long as it is applied (F.). (See Appendix.) The application of boroglyceride (50-per-cent solution) every hour during the day, and the lotion at night, usually gives relief to the patient during the hot weather. Randolph reports the best results from an ointment of salicylic acid in lanolin, 2 to 15 per cent, rubbed well into the conjunctiva daily, preceded by the instillation of cocaine for its anæsthetic effect.

Among local remedies, one which has produced the most relief is the ichthyol prescription (Formula 31) given in the Appendix. This is followed by applications of chinosol (1 to 2,000), applied three or four times daily. Suprarenal extract with chloretone often affords temporary benefit.

The author has obtained the best results from the grattage operation in cases of this kind. *It should always be performed,* even in patients of four years of age, as soon as the diagnosis is confirmed.

Prognosis.—The prognosis, as to ultimate recovery without permanent damage to the eye, is very good, although the duration of the attack cannot be foretold, as there is a liability to recurrence of the trouble year after year.

One patient, in my own experience, had a recurrence of the disease for eight consecutive years. The *grattage operation* was performed, and since then there has been no recurrence of the trouble. Five other cases were similarly treated, and with the same gratifying results.

FOLLICULAR CONJUNCTIVITIS

Follicular conjunctivitis is characterized by the presence of small, round, translucent elevations in the conjunctiva, the size of a pin's head or sago grains, situated chiefly in the fornix or arranged in a row parallel to the margin of the lid. They also appear in clusters in the retrotarsal folds, and even extend into the *cul-de-sac*. They are found in young patients, and are accompanied with slight photophobia and painful sensations, which prevent a continuance of close study. This disease often lasts for months, and as it disappears the mucous membrane assumes its normal state. It is the conjunctivitis which appears periodically in large schools, asylums, or prisons, and is infectious. A child having this disease may communicate it to another by means of towels, wash-basins, etc. Whenever detected the child should be isolated, or else the whole school or institute may become infected.

Symptoms.—The symptoms are the same as in ordinary catarrhal conjunctivitis. The distinguishing feature is the presence of the hypertrophied lymph-follicles, which are most abundant upon the lower lid and which show no tendency towards ulceration and subsequent cicatrization.

Treatment.—As soon as a patient is found suffering with the disease he should be isolated, and the eyes thoroughly sprayed with Formula 23 and a mild solution of silver nitrate, 1 grain to 1 ounce, applied once daily. The edges of the lids should be anointed at night with Formula 31.

Rubbing dry boric acid into the enlarged follicles, or touching the everted lid with copper sulphate crayons (a common practice among the Egyptian physicians 1500 B. C.), or alum crayons, and washing away the excess with sterile water or boric-acid lotions, are efficacious measures. This latter operation may be repeated two or three times a week.

The complications that may arise, if the disease is not cut short by prompt measures, are true trachoma and pannus, with aphthous ulcers, which will form along the corneo-scleral margin of the conjunctiva in neglected cases. Among the more recent remedies which have proved beneficial is protargol (5-per-cent solution) dropped into the eye four times daily.

Grattage has been performed with satisfactory results in some cases of follicular conjunctivitis, which proved intractable to medical treatment. Some patients, however, will not give their consent to a surgical operation, and in these cases medicinal treatment should be instituted.

For those patients who will not undergo so radical an operation as grattage, but desire to obtain a quicker cure than can be effected by simple medical treatment, the following operation may be performed:

A Knapp's roller forceps is inserted well back in the conjunctival *cul-de-sac* and with firm pressure pulled away from the eye. This breaks down the follicles and expresses their contents. Unless the retrotarsal fold is thoroughly cleaned, a cure will not be effected. This space can best be reached by rolling the eyelid around the Darrier forceps.

TRACHOMA

SYNONYMS: ***Granular ophthalmia; Granular lids; Granular conjunctivitis; Military or Egyptian ophthalmia.***

Definition.—A contagious inflammatory disease of the palpebral conjunctiva, characterized by increased thickening and vascularity, and the formation of granular elevations, or lymphoid infiltrations which undergo ulceration and subsequent cicatrization.

Causes.—It is due to some form of micro-organism residing in the secretion of the affected membrane, the isolation of which has not yet been accomplished. The disease is nearly always acquired by contact with the secretion, but cases occasionally arise spontaneously. Debilitated individuals seem more disposed than others towards contracting this affection. It is most frequent in barracks, asylums, almshouses, etc., the inhabitants of which are careless in the use of towels, handkerchiefs, and similar personal articles. It was particularly common among immigrants, especially the Jews and the Irish. The American negro seems comparatively immune to the affection. In certain countries such as Egypt, Arabia, and eastern Europe it is extremely prevalent. High altitude seems inimical to it, as it is most common in low countries. The scrofulous diathesis is a predisposing cause. The disease often follows a purulent ophthalmia.

Symptoms.—The disease is usually chronic, although occasionally acute cases may be observed in which there are marked inflammatory symptoms and profuse purulent secretion. These cases resemble purulent conjunctivitis, and often the diagnosis must be withheld until the granulations are visible. It is usually bilateral.

In quite a number of cases the initial course of the disease is so insidious that the patient is not aware of its presence until the case is quite well developed. The changes in the palpebral conjunctiva are slowly progressive; the membrane becomes thickened, vascular, and roughened by firm hemispherical elevations. This change usually takes place first in the upper lid, later extending to the lower lid, giving rise to the growth of considerable organized new tissue in the deep parts of the conjunctiva. Externally, œdema and vascularity of the lids is noticeable, while the ocular conjunctiva is congested and has an angry appearance; slight photophobia and lacrymation are present, and a "gritty" feeling, due to the roughened condition of the palpebral conjunctiva, is experienced by the patient. If the lids be everted in the early stages of the affection, the surface is found covered with small granular bodies, which look very much like small sago grains, scattered or massed together. In the later stages this tissue is partly absorbed and partly converted into dense, tendinous scar-tissue, which, by its shrinking very often, occasions considerable annoyance and deformities of the lids. In all cases the folds and ocular surfaces are very greatly irritated by the roughened surface, producing a host of resultant troubles by mere friction. In many cases the inflammation is intense, the discharge excessive, the cornea becomes involved early, and only prompt and vigorous treatment can prevent complete blindness. The trachoma granules in some cases are deeply embedded beneath the thickened opaque conjunctiva, or in the masses of fibrous tissue that have developed in the lid, so that they can hardly be seen, if at all. The lid becomes swollen, and drops by reason of its increased weight. The palpebral fissure becomes more narrow than normal. There is always a mucopurulent discharge, considerable in amount in acute cases and scanty in those of long duration.

Diagnosis.—The diagnosis can be quite easily established by the presence of the small trachoma granules on the lids, and a drooping of the upper lid which is almost characteristic. The disease may be mistaken for follicular catarrh when the granules are distributed and confined to the retrotarsal fold. In the early stages of the disease, the changes in the conjunctiva, together with the absence of marked discomfort, are quite characteristic of trachoma.

Treatment.—The treatment is directed to the reduction and absorption of the granular formation; this being best brought about by the application of astringents, frequently applied. Strong caustics or astringents may also be used. Weak solutions of silver nitrate are, however, preferred by some ophthalmic surgeons to any other astringents. Protargol, argyrol, and similar silver preparations have been highly recommended. Equal parts of boroglycerin and glycerin are equally efficacious. The daily application of alum or copper sulphate crayons to the everted lids is the principal indication in the less malignant types. Some authorities claim that recovery is hastened by mechanically pressing out the granular formations, and Knapp and Gifford have invented forceps for this purpose. It may also be performed with the thumbnails. The process is, however, somewhat painful, and general anæsthesia should be employed if an extensive area is thus treated. Formula 29 may be applied in the more obstinate cases.

If sulphate-of-copper crayons are used they should be delicately applied to the granular surface, and followed by irrigation. The growth of the granules will generally be cut short by this procedure. Formula 29 is beneficial in all stages of the disease. The dusting of powders such as calomel, aristol, boric acid, etc., well rubbed into the follicles (Bickerton), may also be employed.

Since the disease is highly contagious, it is needless to emphasize the constant need of extreme cleanliness, as well as attention to constitutional treatment and hygiene.

It is sometimes possible to hasten the cure by everting the lid and excising the granular formation with scissors, or by scraping tissue down to the basement membrane with scoop or scalpel.[1]

Grattage.—Much success has attended the grattage operation in the treatment of trachoma. In the author's experience, it gives the quickest and most permanent results.

The operation is performed as follows: The upper eyelid is grasped along its margin by Darier's forceps, and the edge being turned upon itself, the lid is everted until the retrotarsal fold is brought into view. A horn spatula should be inserted beneath the lid to protect the cornea. The exposed part is first thoroughly scarified with a three-bladed scalpel. The granular tissue is then scrubbed with a tooth-brush, which has been steeped in a corrosive sublimate (1 to 500) solution just before being used. Immediately after scrubbing the part is washed with a solution of the same strength. Another portion of the lid is now unrolled, and the scarifying, scrubbing, and washing repeated, until the whole eyelid has been subjected to the treatment. If the lower lid is involved in the trachomatous process, it should be treated in exactly the same way.

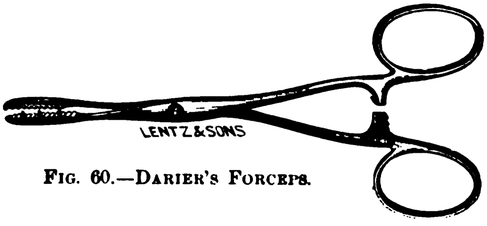

FIG. 60.—DARIER'S FORCEPS.

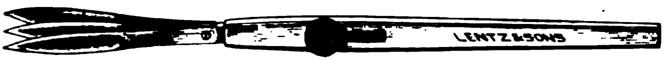

FIG. 61.—DARIER'S THREE-BLADED KNIFE.

Frequently a Burow's operation, cutting through the cartilage from the inner to the outer canthus, performed at the same time aids the grattage by expanding the eyelids. In trachoma the swollen condition of the conjunctiva and cartilage prevent the free movement of the eyeball, and by exerting pressure produce pain, not to mention the danger from pannus. Slitting (Burow) the cartilage relieves this pressure and its consequent danger.

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[1] The author practised this operation as early as 1885. See Fox and Gould's Diseases of the Eye, Quiz-Compends Series.

There is very little reaction to this apparently harsh procedure. The patient is put to bed and a lotion applied (Formula 1). The eye-pads are kept saturated for two or three days, and if the operation has been properly carried out the results are exceedingly gratifying. It rarely happens that the operation must be repeated more than once on the same patient.

The French method consists in everting the eyelid after twenty-four hours and again applying the corrosive-sublimate (1 to 500) solution to the conjunctival surface. This procedure is very painful, and in my experience I have found it unnecessary. The constant application of an antiphlogistic lotion has a better effect (Formula 1).

Within the past year a number of foreign observers, particularly Mayou, Stephenson, and Walsh have used the X-ray in the treatment of this disease with gratifying results.

The galvano-cautery has also been employed, but is of most service in isolated granules.

Electrolysis has been employed by a number of ophthalmic surgeons for the removal of the granulations of trachoma. The method employed by T. D. Meyers, Philadelphia, for this purpose is probably the best, as it is not followed by cicatrices. A 30-cell galvanic battery is employed together with a reliable milliampère-metre. A current of 1½ to 2 milliampères is usually sufficient. The lids should be everted and a 4-per-cent solution of cocaine be instilled for its anæsthetic effect. The needle, attached to the negative pole, is inserted into the granulations, after which the positive pole is placed in contact with the back of the neck. The vessels supplying the granulations should be attacked when possible. The effect of the current is shown by the coagulated material that collects about the needle. The *débris* should be removed by irrigation by means of boric-acid solution. The number of punctures made at a single sitting is seldom more than four or five. For large granulations a wire ring is employed of the same thickness as the needle. Flat electrodes are decidedly less valuable than the needle, and are often followed by scarring. There is very little reaction following this mode of treatment.

Sequelæ of Trachoma.—The troublesome sequelæ of trachoma are all natural consequences of the friction of the roughened palpebral conjunctivæ. As a rule, mere removal of the causal condition affects their disappearance. In certain cases, however, this is unfortunately not true. The cicatrices following the absorption of the granulations may so "pucker" the conjunctiva as to draw the edge of the lid inward, producing trichiasis or entropion; in either case the friction is greater than that directly due to the trachoma. The most frequent and troublesome sequel of trachoma is pannus. Corneal ulcers, staphyloma, symblepharon, ectropion, and xerosis may also occur.

Prognosis.—The outlook is unfavourable in the absence of prompt and appropriate treatment. The resulting scars induce considerable deformity and defects of vision. It tends to perpetual chronicity, and often resists treatment.

PANNUS[1]

SYNONYMS: *Trachomatous keratitis; Superficial keratitis.*

Primarily it is an affection of the corneal epithelium, but since the deeper layers of the cornea become involved, as the result of trachoma, it may be discussed here. It is characterized by a subepithelial infiltration of cells, and distention of capillaries, forming a fine tortuous network extending from the limbus conjunctiva towards the centre of the cornea.

It may be due to the irritation of the granules against the cornea or to the extension of the trachomatous process to the cornea. It is usually due to mechanical irritation.

Symptoms.—Pannus does not arise in the course of trachoma until the latter disease is well established, and there is marked roughening of the inner surface of the eyelids; the upper eyelid being usually the first one to be affected. It generally occurs in those cases in which, on account of the swelling of the eyelids, or for other reasons, the eyes are not kept sufficiently or fully open. Abrasions of the superficial layer of the cornea are quite frequent.

It may develop rapidly, with intense hyperæmia, causing severe photophobia and practically blindness in a few weeks. If trachoma has given rise to cicatricial scars and left the lids markedly deformed, and especially if they press upon the cornea with permanent narrowing of the palpebral fissure, the pannus may remain after the trachoma has disappeared.

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[1] For classification of Pannus, see Vascular Keratitis, p. 149.

Diagnosis.—Pannus is distinguished by innumerable small blood-vessels running down over the cornea, extending to the pupil. Sometimes the whole cornea becomes invaded by these blood-vessels, changing the corneal epithelium to such an extent that vision is practically lost. In such cases it is very difficult to clear the cornea entirely even after the pannus disappears, a translucent haze, due to the morbid changes that have taken place in the epithelial layer of the cornea, persisting. The appearance of the vessels in pannus is sufficiently characteristic to differentiate it from pterygium.

Treatment.—Pannus generally disappears when the conjunctiva and lids are restored as nearly to their normal condition as possible. If this does not occur, peridectomy is advised, this operation usually being successful. It is performed as follows:

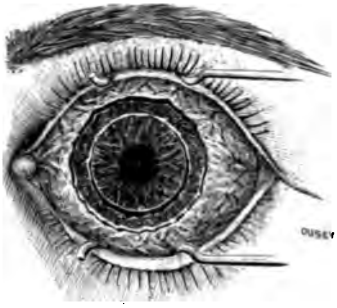


FIG. 62.—PERIDECTOMY.

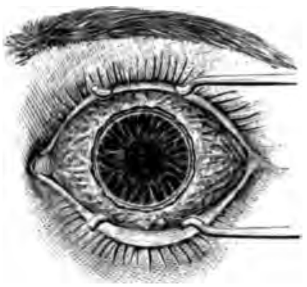


FIG. 63.—PERITOMY.

The eyelids are held apart by a speculum and several instillations of cocaine made in order to anæsthetize the conjunctiva. A fold of conjunctiva near the cornea is grasped by the fixation forceps, and divided by scissors. For partial pannus a band of circumcorneal conjunctiva about 5 millimetres wide is dissected on the side of the engorged vessel. If the pannus be general, a complete circular zone must be cut away, including the subconjunctival tissue to the sclera, in order to form a dike of cicatricial tissue against the convergent vessels. In cases of pronounced pannus, a circular incision of the corneal blood-vessels by means of a Beer knife is necessary. The ordinary peritomy operation consists merely in dividing the conjunctiva at the corneal limbus for its entire circumference.

The author has found it advisable at times to defer peritomy or peridectomy for a week or two, as the grattage operation frequently acts beneficially upon the pannus.

Although immediately after a peridectomy it appears that matters have been made worse, a satisfactory outcome is the rule. Energetic massage of the eyelids sometimes seems to give relief. Photophobia and pain are usually much lessened by instillations of atropine, or one of the other mydriatics.

An artificial purulent ophthalmia, produced by the instillation of an infusion of jequirity seed (3 parts pulverized seed in 500 parts water) is sometimes employed to relieve the corneal irritation and cloudiness. A more recent treatment is that advised by Dr. Carl Hood (1903), in which jequiritol or jequiritol serum is employed. The inflammation thus produced is allowed to run its natural course, and, if the treatment is successful, the cornea should lose its cloudiness within about two weeks' time after the inflammation has begun. The advantages of this procedure are certainly very doubtful, since it is not possible to regulate the inflammation, but it is infinitely preferable to the pernicious practice of inoculating the eye with gonorrhœal pus, which formerly had a certain vogue. If a syndectomy or peritomy has been performed this procedure becomes less dangerous.

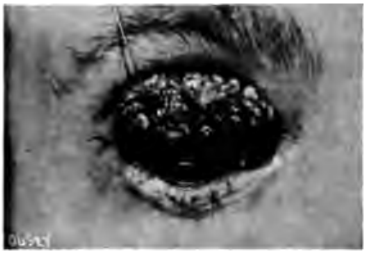


FIG. 64.—TUBERCULOSIS OF THE CONJUNCTIVA.

Prognosis.—Absolute recovery never follows a severe case of pannus, although there may be restoration of good vision.

Tubercular Conjunctivitis.—Tuberculosis affecting the conjunctiva has been described, and as a rule involves but one eye. It presents a clinical appearance not unlike that of trachoma, but the ulcers are of greater size. Other forms of tuberculosis nearly always can be demonstrated elsewhere in the body.

The treatment is largely supportive in character. The local lesions should be destroyed when possible. The local treatment of trachoma is applicable also in this disease. The outlook is unfavourable. In a case of tubercular conjunctivitis recently reported by Sidney Stephenson a cure was effected by the X-ray.

Parinaud's Conjunctivitis.—An inflammatory condition of the conjunctiva resembling acute trachoma, characterized by large polypoid granulations and ulcerations. It attacks but one eye at a time, and is attended by swelling and œdema of the lids and a muco-purulent discharge. Adjacent lymphatic glands are usually enlarged, and may suppurate. There is always more or less constitutional disturbance. The duration varies from a few weeks to several months.

The rarity of the condition has prevented the mapping out of any specific treatment, but the employment of mild antiseptic and sedative eye-lotions and measures tending towards the destruction of the granulations has been of value in most cases. Recurrences are frequent.

PTERYGIUM

Definition.—A vascular thickening and extension of ocular conjunctiva and subconjunctival tissue upon the cornea.

The growth is roughly triangular in shape, with the apex pointing towards the centre of the cornea, and the base at the corneal margin—usually on the nasal side. The condition most frequently occurs on but one side of the eye, but several cases in which a pterygium has existed at the inner and outer canthus of the same eye have been encountered by the author.

Causes.—The condition in all probability arises from the constant irritation of dust or other foreign particles that may gain an entrance into the conjunctiva, and is common in individuals exposed to these influences, such as labourers, sailors, cooks, bricklayers, etc. It constitutes about 7 per cent of all ocular affections. It is infrequent in cities, and seldom occurs in persons who lead sedentary lives exclusively. Traumatism and ulcers of the cornea occasionally act as factors in its production. Pinguecula frequently precedes pterygium, and is considered by Fuchs as its cause. Chacon (Mexico) regards pterygium as an evidence of alcoholism, particularly in the natives of Mexico.

Symptoms.—For a long period the presence of the conjunctival growth is attended by no subjective symptoms. It, however, tends to progress slowly but steadily. In the less serious forms it may remain stationary without encroaching upon the pupillary area. In the progressive types the conjunctiva forming the superficial layer of the pterygium is quite vascular and supported by a thickened mass of subconjunctival tissue, the vascularity and thickening extending upon the sclera to the region of the caruncle.

The vascularity and prominence of the pterygium is only marked during the period of growth; at the later stages the growth undergoes partial atrophy, becomes pallid, and loses its vascularity.

The pterygium, except its apex, is loosely attached to the cornea, which is usually normal. The sclerotic portion is also loosely attached. A pseudo-pterygium is often formed as the result of burns or other forms of traumatism to the eye, but is firmly attached to the underlying tissues, and is thus distinguished from the true variety.

This growth does not often give rise to discomfort so long as it does not encroach upon the pupillary region of the cornea, but it is unsightly from an æsthetic standpoint.

Sight is interfered with if the pterygium encroaches upon the pupillary region. If the growth be very extensive, the movements of the eyeball may be interfered with, thus causing diplopia.

The distortion of the cornea by the presence of the growth induces astigmatism of varying degrees, which also lessens visual acuity unless corrected.

Treatment.—The presence of a small and non-progressive pterygium in the absence of subjective symptoms contra-indicates any interference. If the growth is progressing and there is danger of the pupillary area being obscured by it within a very short period, its removal should be advised. Removal of a pterygium may be accomplished by electricity or by a surgical operation. The electric current may be employed in electrolysis or in the galvanocautery, and is best adapted for the removal of small growths. After such treatment the eye should be placed at rest and bandaged. Antiseptic and astringent eye lotions should be employed to combat any tendency towards inflammation. The application of nitric acid has been followed by cure in one case reported by R. O. Shaughnessy (India Reg. Med. Soc., Calcutta, 1848).

Operative Treatment.—There are at present three operations in vogue—excision, ligation, and transplantation.

Excision consists in removal of the entire growth with the application of the cautery to its corneal attachment and suturing of the edges of the conjunctival wound. This method has been superseded largely by the operation of transplantation.

Ligation consists in ligating the pterygium near the sclero-corneal margin, and also near the base of the growth. In this way a large part of the mass is thus strangulated and may be removed in a few days. The ligatures should be passed by needles, and after having been cut, the thread is tied as near the base and apex of the pterygium as possible.

Transplantation is, in my opinion, the best operation for the relief of this condition, and performed in the following manner has given most gratifying results: An incision is made in the conjunctiva above and below the growth, making a pocket which extends to the insertion of the inferior rectus muscle. The pterygium is then separated from the eyeball with scissors, leaving, however, the corneal attachment intact. Two needles are threaded on one strand of silk, and one of them is passed through the corneal end of the pterygium from the upper side downward. The second needle is passed in like manner, but brought out upward, leaving enough tissue between the two threads to hold it. With the strabismus hook the pterygium is separated from its corneal attachment (Prince), and then turned downward into the newly made *cul-de-sac*. The needles, one at a time, are passed through the conjunctiva near the insertion of the inferior rectus muscle, bringing the head of the growth almost in contact with the muscle and holding it in place by the silk thread, which is tied. This brings the raw surfaces of the pterygium against the raw surfaces of the eyeball. The edges of the conjunctiva are brought over the pterygium by two or three stitches, and, while there is some puckering of tissue in the caruncular space at first, it usually disappears.

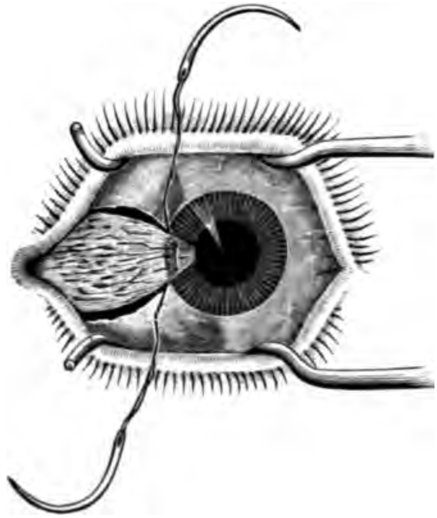


FIG. 65.—PTERYGIUM TRANSPLANTATION, *a*.

The after-dressing is the same as that applied in the ordinary conjunctival or strabismus operation. The stitches are removed after four or five days.

The advantage of transplantation is that the pterygium rarely develops again after this operation; if it should develop, however, the parts are left in a more favourable condition for a second operation. If excision be performed, the loss of tissue makes a second operation more difficult, and more liable to cause impairment of the ocular movements.

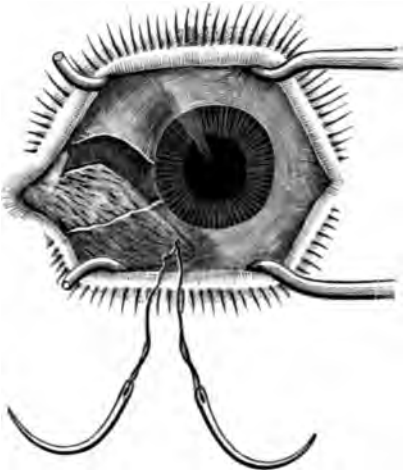


FIG. 66.—PTERYGIUM TRANSPLANTATION, b.

The author has also performed McReynold's operation for pterygium on several occasions, with satisfactory results. This consists essentially in dividing the pterygium close to its apex; dividing the conjunctiva and subconjunctival tissue along the lower margin of the growth and tucking the pterygium into the flap thus made by means of needles.

Other operations have been devised from time to time, and each has its advantages in selected cases. An operation of more or less popularity among ophthalmic surgeons consists in removing the growth from the cornea with as little traumatism as possible by grasping the central portion with fixation forceps and dissecting it from the cornea by means of a Beer knife towards its base. The apex of the growth is then turned over towards the base and fastened there by sutures. The conjunctiva is united over the area from which the growth has been removed. This operation is known as subinvolution.

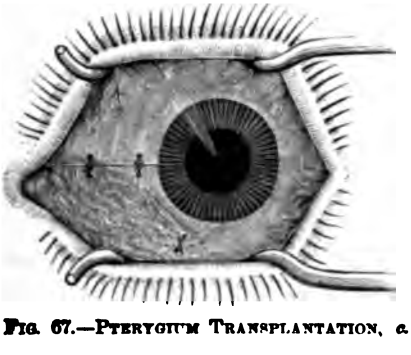


FIG. 67.—PTERYGIUM TRANSPLANTATION, a.

Occasionally the ligature is employed in conjunction with excision in the following manner: The growth is loosened from the cornea by a strabismus hook or a Beer knife and separated from the adjacent conjunctiva by a small pair of scissors. A ligature is then thrown around the growth as near as possible to its base and tied. The edges of the conjunctiva are approximated by sutures, and the knot over the base of the pterygium is examined and made more tight if necessary. The growth is afterward severed near the knot by scissors.

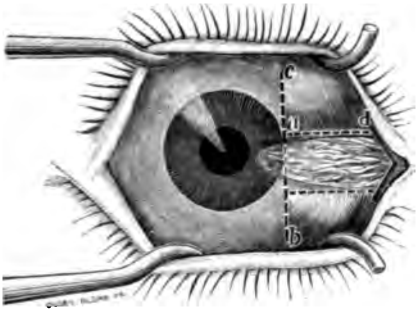


FIG. 68.—HOBBY'S OPERATION, *a*.

Knapp's transplantation operation is performed by splitting the pterygium in its long axis from the apex to the base after dividing its corneal attachment. The flaps thus made are transplanted into the corresponding conjunctival pocket (made by free dissection) and fixed by sutures. The edges of the conjunctiva should then be sutured together. The original operation was intended to transplant the entire growth in the lower conjunctival pocket, but the disfigurement necessitated the subsequent modification of splitting the growth.

Hotz has suggested excision of the entire growth and covering the denuded area with a Thiersch flap of mucous membrane.

Recurrences of the growth are not uncommon, and are more dense than the original. They usually reappear along the line of the conjunctival union, and in order to deflect the recurrence of the pterygia from the cornea, C. M. Hobby (American Journal of Ophthalmology, St. Louis, 1888–91) has devised a very ingenious operation.

The conjunctiva is incised along the upper margin of the pterygium as shown by the dotted line (*a–d*). A vertical incision (*a–c*) is made, extending from the margin of the cornea at right angles to the first. The pterygium is separated from the cornea and the vertical incision is prolonged a trifle lower than the inferior margin of the cornea (*b*). An incision is then made along the lower border of the growth to its base and followed by careful dissection and removal of the pterygium. The upper conjunctival flap should be freed from its underlying attachments and brought down to be secured to the lower fold by two sutures.

The manner in which the operations of the present period for pterygium were perfected is a matter of considerable interest. In 1813 Benjamin Bell recommended and practised scarification of the growth perpendicular to its long axis. It is more likely that this procedure was employed only in the very large growth encroaching upon the pupillary area. Scarpa in the early part of the nineteenth century devised an operation in which the detachment of the head was accomplished by means of forceps. The pterygium was then dissected freely from the conjunctiva in the direction of its base, which was removed concentrically to the cornea 3 to 4 millimetres from its margin. Sutures were not employed. This same operation was performed by Lawrence in 1830, Wharton Jones in 1863, and Abadie in 1876. Fano was the first to complete the operation by the introduction of conjunctival sutures, although this is accorded to Arlt by Fuchs. Transfixing the neck by means of a thread, followed by cutting the corneal attachment and base of the growth, with its subsequent extirpation, was practised by Weller in 1832 and Walton in 1853. Szokalski in 1842 passed three sutures through the growth in its axis in order to strangulate it, and followed this procedure by extirpation on the third day. Desmarres in 1855 detached the pterygium from the cornea and sutured it into the adjacent lower fornix of the conjunctiva. This operation was modified by Knapp and subsequently perfected by Odaiva. Galezowski, in 1880, after freeing the growth from the cornea and adjacent conjunctiva, doubled the growth upon itself so that the apex was in contact with the base, by means of a double thread that transfixed the vertex and extremities of the base, and which was then firmly tied. Prince, in 1885, accidentally detached a pterygium from the cornea by means of a strabismus hook with a successful result. This was later

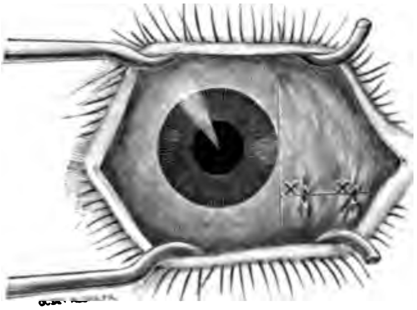


FIG. 69.—HOBBY'S OPERATION, *b.*

adopted as the proper method for relieving the corneal attachment of these growths by Prince, L. R. Dibble, and others, and subsequently a strabismus hook with a cutting edge was devised for this purpose. Pagenstecker and De Wecker detached the growth in every portion except the base, which was allowed to atrophy. The conjunctiva above and below was dissected freely, and united by sutures. Mackenzie's method consisted in raising the growth by grasping its centre with forceps and excising it by one sweep of the scissors. The ends were then neatly trimmed and the edges of the wound united by sutures. Deval modified Mackenzie's operation by passing a thread through the centre of the growth in order to raise it, instead of using the forceps. Panas extirpated the growth and cauterized its point of corneal attachment by the actual cautery.

Various other operations have been devised since the introduction of cocaine as a local anæsthetic, all of which are modifications of those just described.

PINGUECULA

Definition.—The condition characterized by a small, yellowish elevation of subconjunctival tissue, usually on the nasal side of the cornea.

At times it becomes slightly inflamed, and by its prominence causes a certain degree of disfigurement. It has no pathological significance, except that it may precede, and predispose to pterygium.

Treatment.—For the cosmetic effect excision may be performed, or it may be destroyed with the actual cautery. Usually, however, as it does not harm, it requires no treatment.

PEMPHIGUS

SYNONYM: *Primary shrinking of the conjunctiva.*

Pemphigus is a rather peculiar, as well as rare, disease affecting the conjunctiva. The conjunctiva loses its epithelium in spots, which later undergo cicatrization and consequent shrinking. Very rarely bullæ are formed, as in pemphigus of the skin. The whole conjunctiva may finally become obliterated, the sight lost, and the lids firmly adherent to the globe (symblepharon totale).

The disease generally occurs in cachectic patients who suffer from pemphigus affecting the skin, but is also seen in rheumatic patients.

Treatment.—Hygienic measures and internal remedies are to be resorted to and relied on. The internal administration of arsenic is especially recommended in this condition. Soothing eye-washes should be prescribed, and if the disease is once thoroughly checked, skin grafting into the conjunctival sac may be done, and with good results.

Erythema multiforme occasionally makes its appearance upon the conjunctiva as upon other mucous membranes. The lesions include congestion, papules, vesicles, and a false membrane. These manifestations are characterized by their peculiar violaceous colour and are accompanied by injection of the margins of the lids, agglutination of the cilia, a mucoid discharge, and more or less palpebral œdema. The condition lasts from four to ten days.

The treatment consists in the administration of a brisk purgative, followed by cold or similar intestinal antiseptic. Locally, mild antiseptic eye-lotions should be employed.

XEROSIS

Synonym: *Xerophthalmos.*

In this disease the conjunctiva is dry, lustreless, and shrunken. When greatly contracted the conjunctiva ceases to aid in the lubrication of the eyeball, and in place of the normal secretion there is a scanty, muco-purulent secretion. In the later stages spots appear on the conjunctiva tarsi, which are incapable of being moistened by the secretion, and the patient is tormented with a sense of dryness. The condition may spread and involve the entire conjunctiva and cornea. It is probably due to a fatty degeneration of the conjunctiva.

From these spots a bacillus, known as the bacillus of xerosis, may be obtained in great numbers. The disease may be a sequel to trachoma, diphtheritic conjunctivitis, granular lids, or pemphigus. The cornea very frequently participates in the process, becomes dry and opaque, and sight is eventually lost.

Treatment.—Treatment is of no avail. The eyes should be rested, and protected if necessary by dark glasses. The excessive dryness of the conjunctiva should be combated by suitable instillations, such as glycerin and water. A soothing lotion, such as the boric-acid-and-camphor preparation (Formulas 6 and 8) mentioned in the Appendix, should be used. Milk has also been recommended in this connection.

A case came under the author's observation some years ago in which the only relief obtained was by instilling a drop of castor-oil into each eye, every three to five hours. This treatment has been kept up for ten years. The oil clears up the parchment-like condition of the cornea sufficiently to enable the patient to find his way around the city.

At night, before retiring, unguentum boroglyceride should be applied to the margins of the lids.

Tarsorrhaphy (suturing together of the margins of the lids at the canthus) has been mentioned by Tiffany as possessing some value in cases in which the cornea begins to ulcerate and necrosis is threatened.

AMYLOID DISEASE

A rare affection of the conjunctiva, characterized by amyloid infiltration of that structure. It is most frequent in young adults, and is often first noticed by the drooping of one or both lids. Redness, hæmorrhages, and protrusion may become marked, and often render the eye useless. The condition is not unlike trachoma in appearance, but differs from that disease in that it is yellow, waxy, and transparent. The cause is unknown. The treatment consists of excision.

Hyaloid degeneration of the conjunctiva has been observed, but is usually considered a forerunner of amyloid changes.

LESIONS OF THE CONJUNCTIVA DUE TO FOREIGN BODIES, BURNS, AND IRRITANTS

Foreign Bodies.—The conjunctiva is extremely sensitive, and when a foreign body finds lodgment anywhere in the palpebral folds it gives rise to hyperæmia, catarrhal conjunctivitis, and engorgement of the papilla in the location of the foreign substance. It is at times difficult to locate a foreign body, especially when it is lost in the superior *cul-de-sac*, or if it is blown into the eye with considerable force and is buried in the tissue. The foreign substance frequently enters the conjunctiva at one spot and then appears at another, especially when the substance is a particle of glass, granite, or steel. Often the pain is very acute, increasing with each movement of the eyelid.

The larger number of foreign bodies, such as coal dust, are loosely attached to the ocular conjunctiva and are easily removed. A drop of cocaine (5-per-cent solution) should be instilled in the palpebral aperture and the foreign body may then be removed without causing pain. It is necessary, at times, to use focal illumination to aid in the location of a very minute body.

When a small piece of glass is buried in the conjunctiva and only the sharp edge is protruding, it is impossible to see it with the naked eye, then it is best to locate it with a spud by delicately touching the glass particle—the patient will assist by informing the operator when the foreign body is touched. A small fold of the conjunctiva, in which it is embedded, is grasped with delicate forceps and is excised with scissors. The tissue that is removed must be examined under a magnifying lens or microscope to make sure that the glass or steel has been brought away. The author has had three cases recently of this character, and in each this method of locating the glass and removing it has been carried out successfully. However, these cases are rare.

The after-treatment consists in local applications of Formula 7 on cold compresses.

Burns.—Acids, alkalies, etc., cause whitish patches that are very painful, and if extensive, are very serious. The cornea may become implicated, and more frequently the eyelid becomes attached to the eyeball, producing a condition known as symblepharon or ankyloblepharon, in which the margin of the lids become attached to each other.

The treatment must be prompt. In acid burns vinegar or carbonate of potash is recommended. In burns from alkaline substances, such as lime or whitewash, caustic potash, etc., milk, oil, unsalted butter, or vaseline should be applied as soon as possible. Formula 1 is soothing when applied with absorbent cotton dabs. This may be made cold by placing the cotton in an iced bowl, as described in the treatment of Purulent Conjunctivitis. Adhesions between the eyelids must be prevented. This may be accomplished by inserting a conformer and allowing it to remain between the eyelids for ten days or two weeks. Skin-grafting may be necessary, but should be postponed until reaction has subsided. The prognosis is always serious, and an opinion should not be given as to the outcome of the injury until after the third day.

Irritants.—The use of atropine, duboisine, cocaine, and eserine, particularly atropine and cocaine in a certain percentage of individuals, possess irritating qualities, and not infrequently induce conjunctivitis of a catarrhal type. The patients are usually of the blonde type, with delicate skins. When such cases are found the drug must be discontinued and the alkaloids changed, or else combined with an astringent.

The author has found that atropine poisoning takes place in 1 to 4,000 patients, and cocaine in 1 to 200, in prolonged use of the drugs.

Irritative conjunctivitis may also follow the application of calomel powder to the eye, the aniline dyes accidentally introduced, stings of insects, and stimulating ointments used for skin diseases in the immediate neighbourhood of the eyes.

Treatment.—In all cases the employment of the irritant should be discontinued. The treatment is similar to that recommended for a simple conjunctivitis (Formula 8). Silver nitrate, ½ grain to 1 dram, followed by Formula 8, locally, is very beneficial.

TUMOURS OF THE CONJUNCTIVA

Carcinoma is not an infrequent growth of the conjunctiva, and usually begins at the sclero-corneal margin. Its growth is slow, and as it advances it often becomes papillomatous or warty in character. Its further progress is marked by destruction of tissue and subsequent malignant course.

Sarcoma may begin at the limbus or on the inner surface of the upper lid. It becomes pedunculated in a short time and extremely vascular. It bleeds upon slight irritation, and may be pigmented.

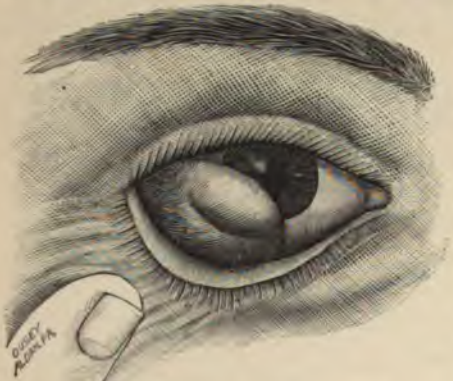


FIG. 70.—LIPOMA OF CONJUNCTIVA.

The treatment of these growths consists usually in the removal of all diseased tissues by free excision. The application of the

X-ray is productive of great benefit without the deformity so common in excision.

Polyps occur occasionally in the plica semilunaris or lacrymal caruncle; they bleed easily, and are pale-red in colour.

Lipoma, or fatty tumour, is a congenital growth of the conjunctiva, having a rough, lumpy surface and a yellow colour. It is most often found in the upper and outer quadrant, and lies beneath the conjunctiva.

Cysts may form in the conjunctiva as the result of traumatism, but are usually congenital. They may arise from dilated lymph-vessels or from the sac of a cysticercus cellulosæ. Dermoid cysts are occasionally encountered, and are always congenital. They nearly always remain quiescent, and are distinguished by their characteristic contents common to all dermoids.

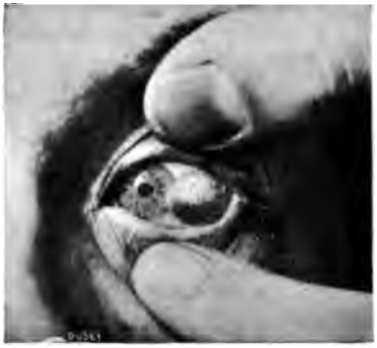


FIG. 71.—DERMOID CYST OF CONJUNCTIVA.

The *treatment* of all these tumours is removal.

Syphilitic growths, such as chancre and moist papules, should always be carefully differentiated from these growths, as their occurrence in this situation is not rare.

Lupus vulgaris or **lupus erythematosus** may involve the conjunctiva by extension from the face. They present no characteristic symptoms in this situation. The treatment should be directed towards the original area of disease. The prognosis is favourable in all cases.

Wounds of the conjunctiva arising from burns, scalds, injury, etc., should always be treated promptly to prevent cicatricial deformities. Incised or lacerated wounds should be united by means of sutures, and granulating surfaces in apposition should be kept apart. Symblepharon and ankyloblepharon are the most common deformities, and are described at length under diseases of the eyelids.

The prognosis is favourable.

SUBCONJUNCTIVAL EFFUSIONS

Effusions of Blood, Ecchymosis.—Effusion of blood beneath the conjunctiva is characterized by a patch or deep red ring surrounding the cornea, and gives to the eye an alarming appearance. It is produced by any operation involving the ocular conjunctiva, by blows, lifting heavy weights, vomiting, whooping-cough, fractures of the orbit or base of skull, and riding through the air at a very rapid rate. Again it is found in certain degenerated conditions of the blood-vessels, such as Bright's disease, scurvy, cholera, etc. They are only important from their symptomatic signification. Their absorption is slow, sometimes occupying two or three weeks. Formula 1 applied three times daily hastens absorption.

Serous Effusions.—When this appears the conjunctiva is swollen and extends over the cornea, causing it to appear as if the cornea were buried deep in the conjunctiva. It may even extend between the margins of the lids. This œdema is always a symptom of an inflammatory process somewhere about the eye or eyelid; it is found associated with such inflammatory diseases as erysipelas, abscess of the lacrymal sac, or abscess of the orbit. It is not an uncommon symptom of cardiac or renal diseases.

The treatment consists of puncturing the conjunctiva and instilling 5 to 10 drops of adrenalin (1 to 3,000) three times daily, and also applying Formula 1.

A somewhat similar condition is present after the subconjunctival injection of salt solution as recommended in diseases of the vitreous, corneal opacities. The large bleb formed usually subsides in about one hour, due to absorption of the saline solution.

CHAPTER VI

DISEASES OF THE CORNEA

GENERAL CONSIDERATIONS

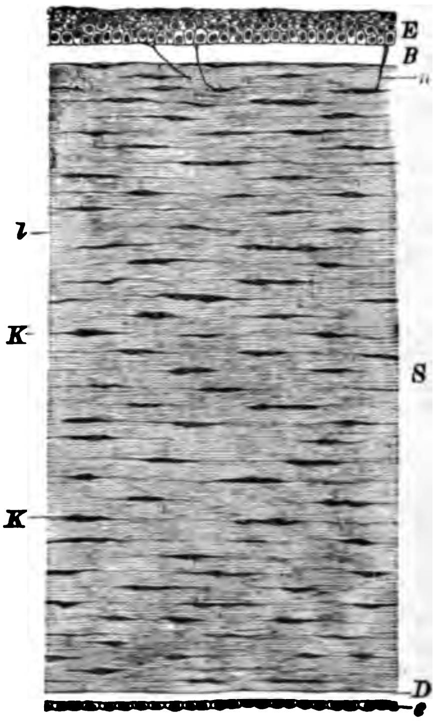


Fig. 72.—Cross-section through a Normal Cornea. Magnified 100 × 1.

E, anterior epithelium; *B*, Bowman's membrane; *S*, stroma, composed of the corneal lamellæ, *l*, and the corneal corpuscles, *K*; *D*, Descemet's membrane; *e*, posterior epithelium; *n*, nerves extending through Bowman's membrane and the epithelium.

On account of the cornea being a non-vascular structure there is in the milder forms of inflammation no congestion, though in all varieties of keratitis the blood-vessels of the conjunctiva and sclerotic coat become more or less involved. Inflammation of the cornea occurs either as a primary or secondary affection.

In various kinds of opacities, phlyctenulæ, or abscesses, it becomes the seat of exudation, which may produce only a faint dimness or haziness of the cornea, or may give rise to quite an opalescent or even salmon-yellow appearance. Any of the five layers of the cornea may be involved, but for simplicity's sake, and so that the student may more easily grasp the subject, this structure has been divided, pathologically considered, into three principal layers: (1) *Epithelial layer* and *Bowman's membrane*; (2) *cornea propria*, or *substance proper of the cornea*; and (3) *Descemet's membrane and endothelial layer.*

In involvement of the first coat, the inflammatory exudation raises the epithelial layer in the form of a phlyctenule, or there may be a slight haziness without any disturbance of the epithelium. Slight congestion of the conjunctiva at one sector of the corneo-scleral margin may be present, or there may be a complete circular involvement.

In involvement of the second coat, the product of exudation enters into the interstitial layer (Recklinghausen spaces) of the cornea propria; hence there may be irregular patches of cloudiness, or if exudation is more extensive, a more pronounced opacity may result. The sclerotic blood-vessels are more or less congested in this form of inflammation.

When the third coat (fourth layer, histologically speaking), Descemet's membrane, is involved, we find haziness of the deepest layers with minute dots scattered about over the endothelial layers, keratitis punctata, or more or less turbidity of the aqueous of the anterior chamber. Here, also, the sclerotic blood-vessels (pericorneal) are more or less congested.

The varieties of these morbid conditions will be more fully described under the different diseases in which they are classified.

KERATITIS

Phlyctenular Inflammation of the Cornea

SYNONYMS: *Keratitis; Pustular keratitis; Strumous keratitis; Scrofulous ophthalmia; Photophobia infantum (scrofulæ).*

Definition.—This is a superficial inflammatory process of the cornea, characterized by the presence of phlyctenules (blisters), and accompanied by slight redness of the conjunctiva and intolerance of light. It is generally situated near the corneo-scleral margin, and occurs most frequently in children from two to fifteen years of age.

Ætiology.—It occurs most often in individuals of a strumous diathesis, but inherited syphilis may be a factor in its production; it may also be due to want of nourishing food, exposure, or lack of cleanliness. Rare cases have been attributed to malaria. The disease frequently coexists with phlyctenular conjunctivitis. It may follow the infectious fevers, and is common in children with adenoid vegetations in the naso-pharynx and with general lymphatic enlargement. By some observers micro-organisms are held to be the cause of the corneal condition by local infection.

Pathology.—The phlyctenules are small elevations of the corneal epithelium, generally situated near the corneo-scleral margin, though occasionally scattered over the corneal epithelium, inclosing a serous fluid which contains broken-down cells and bacteria, but rarely pus-corpuscles. This fluid accumulates until the phlyctenule ruptures, allowing it to escape and leave behind a minute rounded ulcer. The ulcer usually heals rapidly under proper treatment, a small nebula and some irregularity of the corneal surface remaining.

Symptoms.—There is superficial circum-corneal injection, blepharospasm, and excessive lacrymation, often accompanied by epiphora and intense photophobia. The patient complains of a sense of heat or a gritty feeling in the eye. The diagnosis is not difficult.

Treatment.—Internally, the administration of such tonics as Fowler's solution of the arsenite of potassium, combined with the syrup of the iodide of iron, hypophosphites, cod-liver oil, protonuclein, or the elixir of iron, quinine, and strychnine, is indicated in all cases.

The following formula is much used in children from five to fifteen years of age:

℞ Liq. potass. arsenit............................ ʒij;
Syr. ferri. iod.................................. ʒiv;
Syr. limonis............................q. s. ad ℥iij.

M. Sig.: Teaspoonful three times daily.

Locally—insufflations of calomel, finely pulverized, or the application of the following salve will be of great benefit:

℞ Hydrarg. oxidid. flav........................ gr. $\frac{1}{8}$;
Atropin. sulph.............................. gr. $\frac{1}{4}$;
Petrolatum .... ʒj;
Ol. rosæ ....q. s.

M. ft. Ung.
Sig.: Apply a piece the size of a canary-seed to the eye.

Dark glasses should be worn on account of the intense photophobia, in preference to the bandage so frequently employed. The

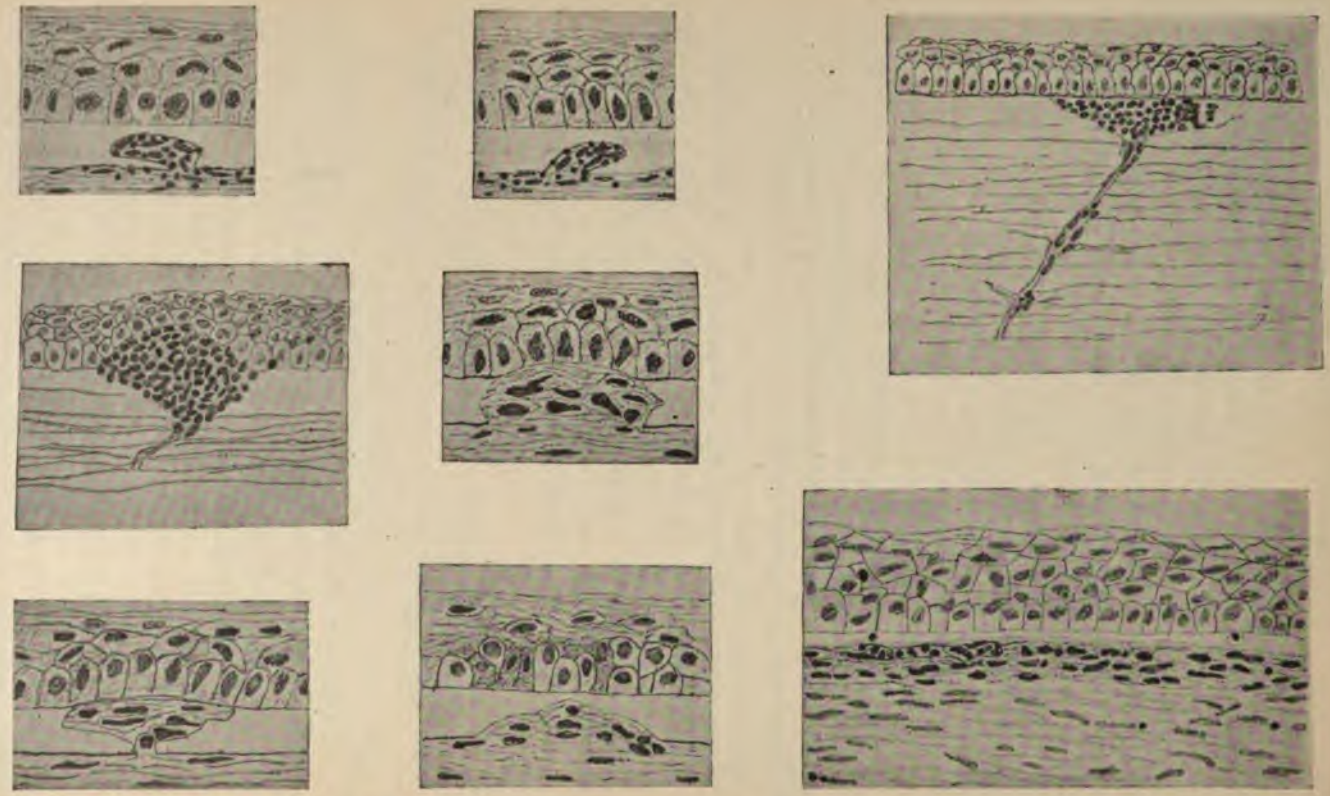


FIG. 73.—PHLYCTENULES IN VARIOUS STAGES OF DEVELOPMENT.

occurrence of true corneal ulceration requires more vigorous local treatment. (See Ulcers of the Cornea.)

Sometimes the disease becomes intractable and does not respond to ordinary treatment. The blepharospasm is often so intense that it is necessary to give the child an anæsthetic to stretch the eyelids with lid retractors in order to break the spasm of the orbicular muscle. The ordinary boracic-acid lotion should be used frequently during the day.

℞ Acid boric, }
Sodii chlor. } ....āā gr. xx;
Aq. menth. pip........................... ʒiij;
Aq. camph., }
Aq. destil. } ....āā ʒij.
M. S.: Eye lotion.

Such hygienic measures as fresh air, proper food and clothing, as well as salt baths twice or three times weekly, should be prescribed in addition to medication. The author has frequently found the most beneficial results follow salt baths, general massage, and sponging the body with alcohol.

Prognosis.—In the majority of cases the prognosis is good, provided proper treatment has been promptly instituted. The healing process is slow in the more severe cases, and after repeated attacks more or less cloudiness and scarring of the cornea is always left behind. Relapses are quite frequent, and after several attacks the eye cannot be restored to its normal condition. As a result of the extensive vascularity the cornea remains permanently clouded. In consequence of this vascularity ulcers sometimes form that may lead ultimately to perforation of the corneal tissue.

INTERSTITIAL KERATITIS

SYNONYMS: *Parenchymatous keratitis; Syphilitic keratitis; Diffuse keratitis; Strumous keratitis.*

Definition.—Parenchymatous or interstitial keratitis, as the term indicates, is a diffuse chronic inflammation of the entire corneal tissue of constitutional origin, involving the cornea proper and elastic laminæ. It is characterized conspicuously by the absence of any tendency towards the loss of corneal tissue, suppuration or vascularization being very rare in this form of keratitis.

There is, on the other hand, deposition of some exudative substance within the cornea that causes an opalescent opacity.

Ætiology.—It is accepted that inherited syphilis is responsible for the majority of cases. Jonathan Hutchinson (London) estimates 50 per cent of the cases to be due to it. He was the first to call attention to the notched and "pegged-shaped" teeth seen so frequently, and to show their relation to the constitutional disturbance causing this corneal disease. The affection is more frequent in girls than boys, and appears usually during second dentition. Even in adults, congenital syphilis may be considered the most common cause. A lymphatic, scrofulous, gouty, or rheumatic diathesis, as well as climatic vicissitudes, and the acute infectious fevers, particularly malaria, contribute also to the ætiology.

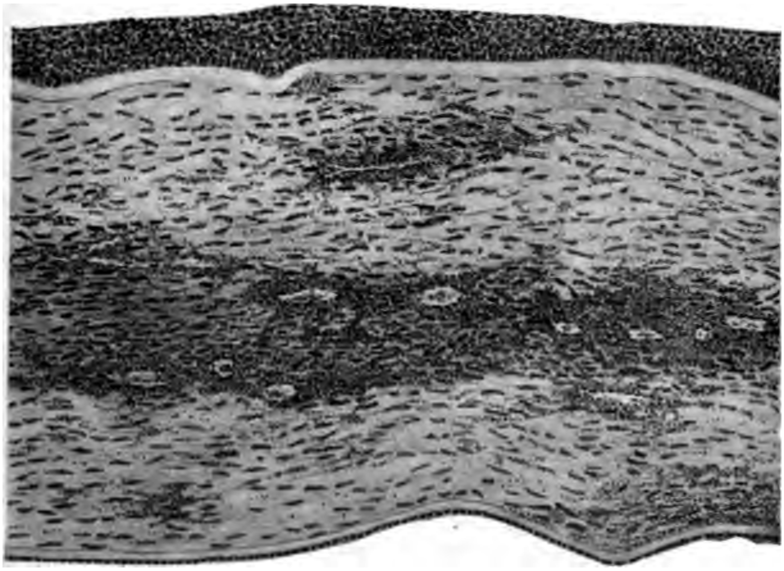


FIG. 74.—INTERSTITIAL KERATITIS, CROSS-SECTION OF CORNEA. (Magnus.)

Symptoms.—The initial symptoms of this disease are more or less ciliary injection, cloudiness or dulness of the cornea, some lacrymation, and interference of vision. The "steaminess" or "ground-glass" opacity usually commences at the centre of the cornea, gradually spreading over the entire corneal surface. Occasionally it may begin at the periphery and gradually extend towards the centre. In the more severe cases it reduces vision to little more than light perception.

Examination by means of a magnifying glass reveals the fact that the substance producing this opacity is situated in the deep layers of the cornea, together with an irregularity in its surface, due to the pathological processes in that structure. Vascularization of the cornea by extension of the anterior ciliary vessels is frequent, producing the discoloration of the cornea known as the "salmon patch." Subsidence of the inflammation at this stage requires a period varying from eight months to one and a half years.

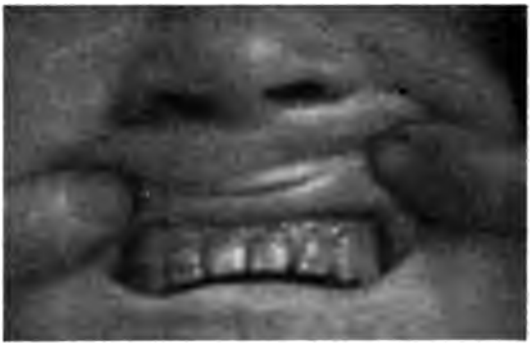


Fig 75.—Hutchinson Teeth.

Iritis and the formation of posterior synechia are not uncommon in less benign cases. There may be an accompanying retinitis, and the whole uveal tract may sometimes become involved. Both eyes are generally implicated, but seldom, if ever, simultaneously, the process in one eye being usually more extensive than in its fellow. Usually the disease appears in the second eye just as the inflammation is about to subside in the first eye. If the cornea is decidedly swollen, a deposition of gummatous material should be suspected; while this endangers the transparency of the cornea, it does not, however, result in suppuration.

The subjective symptoms include photophobia, lacrymation, more or less pain, and interference with vision proportionate to the degree of corneal infiltration.

Diagnosis.—The diagnosis of this disease is not difficult, especially in cases of syphilitic origin. In a characteristic case of syphilis we have the following appearance: Square forehead, prominent frontal eminences, Hutchinson lines or scars about the angles of the mouth, and notched and "pegged-shaped" teeth.

Treatment.—This may be local, constitutional, or both—constitutional being of greater importance. The drug *par excellence* is mercury, and this may be given in most any form. According to the experience of the author, the best forms, however, are the powder of mercury and chalk for internal administration

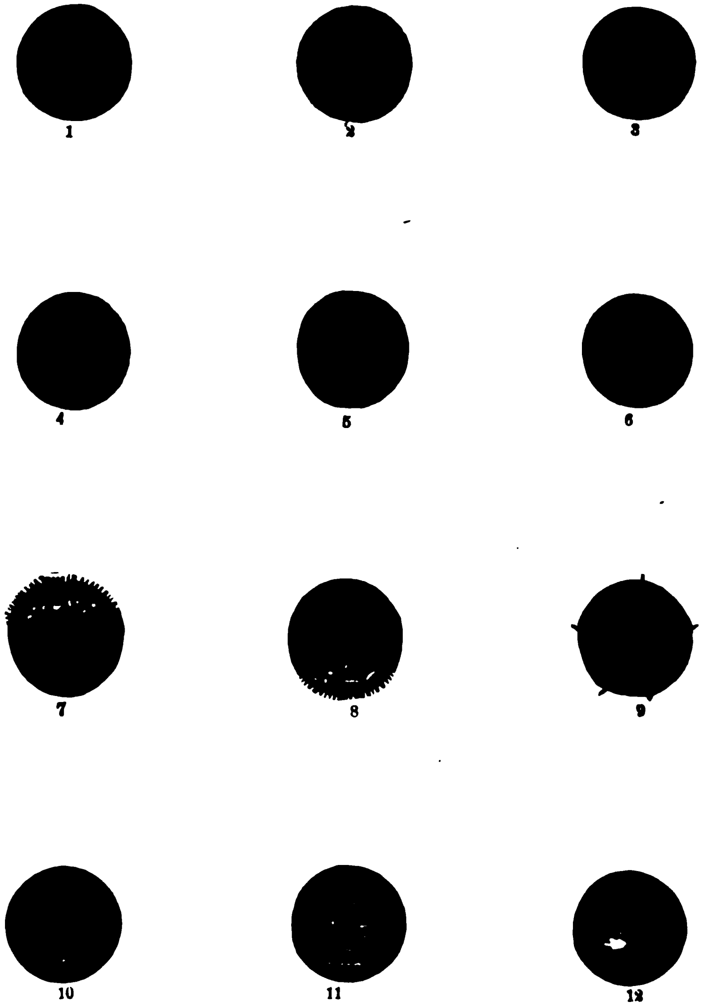


FIG. 76.—KERATITIS.

1, 2. Advancing stage of interstitial keratitis; 3, subsiding stage of interstitial keratitis; 4, terminal stage of interstitial keratitis; 5, 6, vascular diffused interstitial keratitis; 7, 8, 9, pannus, or vascular keratitis; 10, keratitis punctata, descemetitis; 11, sclerosing keratitis; 12, lead pigmentation of the cornea.

and the mercurial ointment in inunctions. In fact, it is astonishing to note the large amount of mercury a patient who is suffering with this disease is able to bear. The author very frequently rubs into children, ten years of age, as much as 10 to 12 ounces before ptyalism makes its appearance, 4 drams being the quantity vigorously applied to the skin daily. The great secret to success is the hard and constant rubbing for a period ranging from ten to fifteen minutes. Different parts of the body shall be selected for each inunction to avoid undue cutaneous irritation. The persons to whom the rubbing is entrusted should wear rubber gloves to prevent mercurialization of themselves. The general nutritive processes should also receive attention; hence tonics are indicated, such as Fowler's solution in combination with the sirup of the iodide of iron. Care should be exercised that the patient refrain from the performance of any mental or physical work, although mild outdoor exercise, as walking, driving, etc., should be advised. Nutritious foods are indicated, selecting those that contain an excess of carbohydrates; but tea, coffee, beer, etc., should be eliminated from the diet. The movement of the bowels should be free at all times, and in order to maintain regularity of the intestinal movements, it is often necessary to resort to mild, unirritating purgatives.

During the administration of mercurial inunctions *pharyngitis* may develop; it then becomes necessary to temporarily suspend the administration of all mercurial preparations. Instead of mercury, iron in medium doses should be substituted. The soreness of the mouth may be greatly relieved by freely and frequently cleansing with tincture of myrrh or chlorate of potassium in water, or the internal administration of tincture of belladonna, 5 to 10 drops three times daily. After the pharyngeal inflammation has subsided, mercury may again be administered. In milder cases the vin ol. morrhuæ comp. (Hostelley's), which contains cod-liver oil and mercury, will bring about a cure. Attention to the personal hygiene of the patient is of the greatest importance. Fresh air, frequent bathing, outdoor exercises, should never be neglected.

The local treatment consists in a regular instillation of the atropine solution (1 grain to 3 drams) once daily; the constant mydriasis aids in preventing iritis; also allays the slight irritability of the eye, and reduces the pericorneal redness. If there is excessive hyperæmia, decided benefit is derived from the application of leeches to the temple, immediately behind the external angular process.

Relief for the photophobia may be obtained by wearing plane dark glasses constantly.

After the disease has reached its fastigium, the absorption of the exudate gives rise to the clearing of the cornea. This may be greatly hastened by the application of an ointment consisting of the yellow oxide of mercury, $\frac{1}{8}$ grain; daturine sulphate, $\frac{1}{4}$ grain; vaseline, 1 dram.

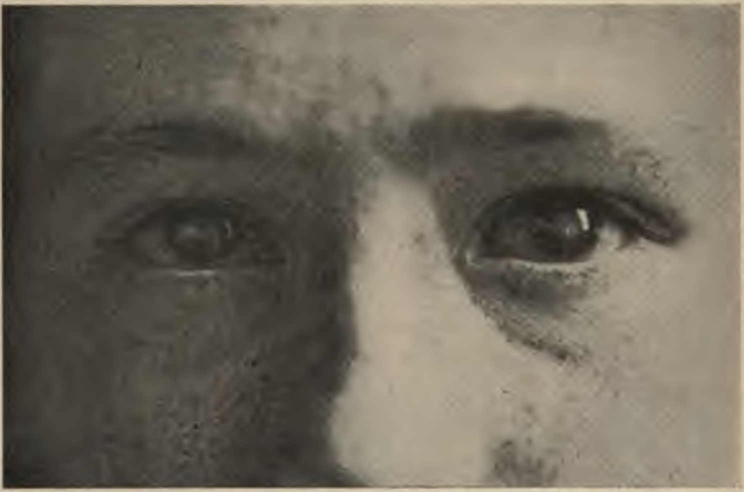


FIG. 77.—CORNEAL OPACITIES FOLLOWING INTERSTITIAL KERATITIS.

For the absorption of the corneal opacities after acute symptoms have subsided, and sometimes during the acute stage, I have had most gratifying results from the subconjunctival injections of salt solutions in strengths varying from 0.6 to 10 per cent. The formulæ employed are as follows:

℞ Sodii chlorid.	gr. v;
Aq. destil.	℥j.

M.

Sig.: Inject 10 to 20 cubic centimetres beneath the conjunctiva every second day.

℞ Sodii sacch.	gr. xv;
Aq. destil.	℥j.

M. Sig.: Inject 10 to 20 cubic centimetres beneath the conjunctiva every third day.

The author's experience has led him to adopt the above formulas. The sodium sacch. has given better results in ulcers of the cornea, interstitial keratitis, iritis, and irido-cyclitis, than the normal salt solution, and it is less painful in the same strengths at the time of the injection and subsequently. It must be understood that this line of treatment is applied in conjunction with other local treatments described above.

The distention of the conjunctiva usually disappears in three hours, and no untoward symptoms follow. Immediately after the subconjunctival injection—for this purpose a Lüer glass syringe is used—the following antiphlogistic lotion is applied to the eye to reduce the swelling:

℞ Liq. plumbi subacetatis dil.	ʒij;
Tinct. opii, Tinct. belladonnæ,	āā ʒiss;
Tinct. arnicæ	℥j;
Aq. camph. Aq. destil.	āā q. s. ad ℥iv.

M.

S.: For local application to the eye.

Prognosis.—The prognosis depends largely upon the severity of the disease and the continuation of appropriate treatment. The younger the individual, the more favourable the prognosis. The opacity of the cornea gradually disappears under appropriate treatment after a period varying from a few weeks to several months. This clearing process usually begins at the margin and gradually extends towards the centre, the central clouded area being the last to disappear. In many instances, however, even after the deposited material has been absorbed, minute channels remain in the corneal tissue throughout the remaining period of life, producing some imperfection in vision. Relapses of the disease are not uncommon and vision is lessened after each distinct attack. Notwithstanding such conditions, the author has seen the cornea in almost hopeless cases clear up and the patient obtain useful vision.

In presenting a prognosis, it is a good rule at the onset of the disease to predict that the sight will become impaired, and that it may perhaps remain so; it is permissible to say that improvement will occur only after the disease has reached the fastigium.

Among the sequelæ of the interstitial keratitis may be mentioned hazy cornea, iritis, irido-cyclitis, posterior synechia, and anterior synechia.

KERATITIS HERPETICA

Sand-blast keratitis; Keratitis superficialis punctata; Keratitis subepithelialis centralis.

A rare form of corneal inflammation, which attacks only the epithelial layers of the cornea. The inflammation commences at the top of the cornea and advances slowly downward until the whole of the epithelial surface is involved. It is almost invisible to the naked eye, and can only be seen clearly under a magnifying lens or a corneal microscope. To the naked eye it has the appearance of being studded with minute points, like a sand-blast surface. Under the corneal microscope the epithelial layer of the cornea is dotted with isometric spaces (facets) of denuded epithelium. On account of the exposure of Bowman's membrane, or more probably the nerve endings in the cornea, the disease is associated with more or less pain. Its sand-blast appearance causes it to resemble an herpetic condition, but there is complete absence of true vesicle formation, the spots being probably due to enlarged or opaque corneal corpuscles or to the filling of the lymph spaces with opaque material.

There is very little or no pericorneal injection of the conjunctiva in the milder forms; it is only when the whole of the epithelium seems to be exfoliated that a redness of the ciliary zone is noticed. The impairment of vision is in proportion to the degree of epithelial involvement and its location.

Treatment.—Internally, full doses of quinine sulphate, iron, and strychnine, or Fowler's solution of the arsenite of potassium should be administered. Locally, insufflations of levigated calomel are employed. As an eye-salve, the following formula is useful: Hydrarg. ox. flav., grain $\frac{1}{8}$; daturine sulph., grain $\frac{1}{4}$; ichthyol ammon., grain ¼; petrolatum, dram 1. This line of treatment brings about restoration of the epithelium. In very severe conditions it becomes necessary to apply a 5-per-cent solution of trichloracetic acid once every second day. Hot fomentations (120° F.) of poppy-heads should be applied constantly to relieve pain.

Prognosis is favourable; the disease runs its course from one to six weeks without any permanent disturbance of vision.

VASCULAR KERATITIS

Pannus.

A superficial vascular keratitis, the result of some irritating influence such as trachoma, trichiasis, or entropion. It is nature's effort to protect the cornea from injury by the hard cicatricial tissue found in granular lids. The pannus may exist in any form of granular lids, even when the papillæ are soft and gelatinous.

It is classified under three varieties: *Pannus tennis,* very slight vascularity; *pannus vascularis,* increased vascularity of the cornea; *pannus crassus,* or *carnosus,* in which the cornea is extremely vascular and assumes a red, fleshy appearance.

Pathology.—The blood-vessels form a fine and tortuous meshwork immediately beneath the epithelial layer, extending from the limbus of the conjunctiva towards the centre of the cornea. In long-standing cases the author has seen Bowman's membrane considerably changed by the invasion of new-formed blood-vessels and pathological products. In such cases the cornea always remains slightly cloudy. The condition is believed by some to be a part of the trachomatous disease and not merely the result of irritation. It is accompanied by destruction of the corneal epithelium, and disappears with its regeneration.

Treatment.—When due to trachoma, the grattage operation should be performed at once, and this should be followed immediately by Burow's operation (an incision of the cartilage from the inner to the outer canthus). The author has performed peritomy in all cases where the lids are apparently smooth, and yet the pannus persists. The treatment should always be directed towards the granulations or similar conditions of the lids that may be considered causal. Some of the older authorities advocate the pernicious practice of inoculating the palpebral sac with the discharge of ophthalmia neonatorum or the infusion of the jequirity-bean in cases of trachoma. This is mentioned only to be condemned.

Prognosis.—This depends entirely upon the extent to which the deeper layers of the cornea are involved. In most cases the vascularity gradually disappears after the cause has been removed, but in *pannus crassus* of long standing particularly, considerable cloudiness of the cornea is the best that can be expected.

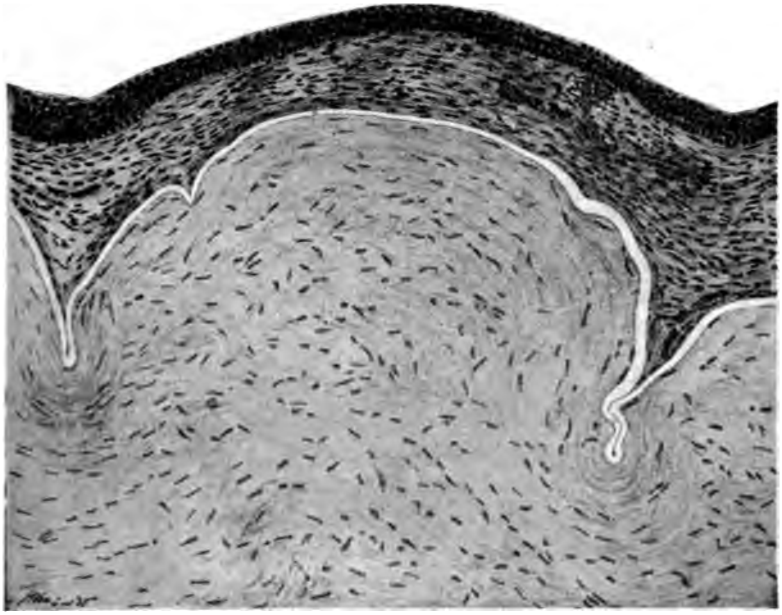


FIG. 78.—PANNUS DEGENERATIVUS. (Magnus.)

SUPPURATIVE KERATITIS

SYNONYMS: *Perforative corneitis; Abscess of the cornea; Serpiginous ulcer of cornea; Hypopyon keratitis; Ring or circular ulcer of cornea; Oyster-shuckers' keratitis.*

Definition.—An inflammatory disease of the cornea, characterized by a suppurative process, resulting in loss of corneal tissue. Phlyctenular inflammation of the cornea may be classified under this heading, but is described usually as a distinct clinical affection.

Ætiology.—This disease may occur at any age, being due primarily to insufficient power of the corneal tissue to resist the action of infective bacteria, such as the staphylococcus pyogenes aureus, Klebs-Löffler bacillus, and the pneumococcus. It may occur as a complication or extension of an inflammatory process in adjacent tissues (purulent conjunctivitis, for example), or as the result of impairment of the general health, as in tuberculosis, rheumatism, and malignant diseases, malnutrition of the corneal tissues, traumatism, and uncleanliness. It is not uncommon as a sequel of lacrymal disease.

There are two varieties of this disease, viz.:

1. Inflammatory.
2. Non-inflammatory, or indolent.

Either of these two varieties may be diffuse or circumscribed. The first type present acute inflammatory symptoms; the second type is characterized by a breaking-down or sloughing of the corneal tissue without pronounced inflammation.

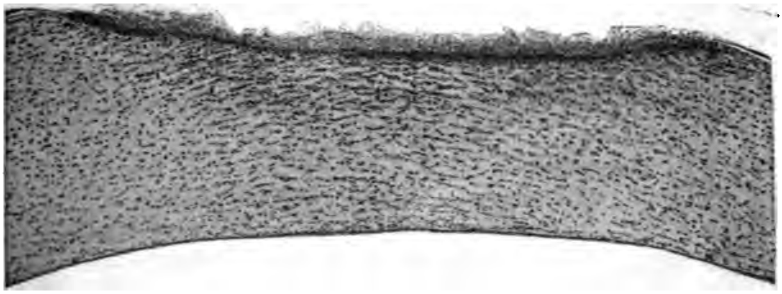


FIG. 79.—SUPPURATIVE ULCER OF THE CORNEA, CROSS-SECTION. (Magnus.)

Symptoms.—If the keratitis is of the inflammatory type the patient complains of intense pain, photophobia, and lacrymation. In the non-inflammatory variety, there may be a total absence of subjective symptoms.

A suppurative keratitis may develop from an apparently simple ulcer, from the rupture of an abscess of the cornea, or from bruised or infiltrated tissue. The symptoms are very similar to those produced by a simple form of ulcer, although usually they are more rapid in their onset and very much more intense.

In the diffuse variety, the cornea loses its brilliancy and assumes a grayish-white appearance, soon acquiring a yellow tinge, due to the formation of pus. The process of infiltration and suppuration goes on very rapidly, the entire involvement of the cornea taking place in a period ranging from a few hours to several days.

Occasionally the deeper tissues (cornea propria and Descemet's membrane) are involved in the sloughing process, which produces a perforation leading into the anterior chamber.

The immediate danger of purulent inflammation of the cornea is perforation. Suppuration of this tissue is always followed by ulceration or destruction of its substance, with consequent impairment of the tissue's transparency. When perforation takes place, the fluid in the anterior chamber escapes, bringing the lens and iris in immediate contact with the posterior limiting membrane of the cornea (anterior synechia). Occasionally the fluid within the eyeball presses against the iris and causes it to be pushed into and through the perforation (hernia of the iris). The presence of pus in the cornea is known as *onyx,* and a similar condition in the anterior chamber constitutes *hypopyon.*

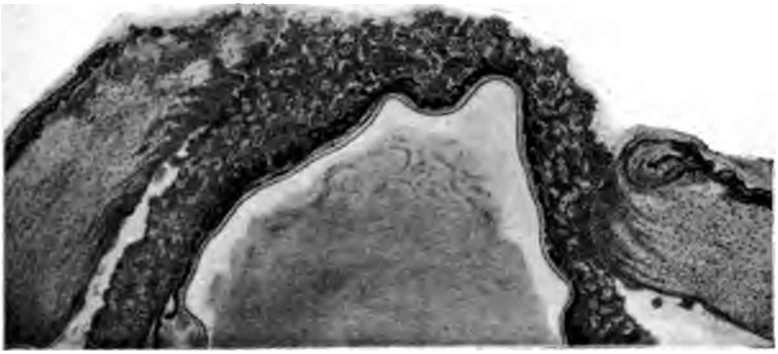


FIG. 80.—PERFORATING ULCUS SERPENS, SHOWING PROLAPSE OF IRIS. (Magnus.)

The ulcerated surface is now rapidly covered by a plastic exudate, which soon becomes organized, forming one mass of scar tissue, and filling up the fistula. Spontaneous cures of perforating ulcers have been frequently recorded. The fluid in the anterior chamber escapes, causing the anterior surface of the crystalline lens to come in contact with the inner opening of the fistula. A plastic exudate is hurriedly thrown out into the fistulous tract and undergoes organization; this fills the opening produced by the disintegrating process and permits the re-accumulation of aqueous humour in the anterior chamber, already partially reformed. As a result of this, pressure is exerted upon the anterior surface of the lens by the fluid, tearing the adhesions, forcing the lens back to its former position, and allowing a complete re-establishment of the anterior chamber. The lens capsule, as a result of these adhesions, may or may not remain slightly opaque.

Treatment.—Atropine (1 grain to 3 drams) should be instilled into the eye twice daily, both for its sedative effect and also to prevent adhesions of the iris to the cornea. Sometimes atropine produces an irritation; if so, daturine should be used instead (1 grain to 3 drams). The ulcer itself should be disinfected as thoroughly as possible by bathing the eye frequently with a very mild bichloride solution (1 to 10,000) and immediately thereafter irrigating it with a sulphocarbolate of zinc or chloride of zinc (2 grains to distilled water, 1 ounce), and 20-per-cent solution protargol. If any foreign bodies, such as dust, steel, etc., are lodged in the floor of the ulcer, they should be carefully removed in order to lessen the irritation.

If the ulcer is of the non-inflammatory type, it should be stimulated to active inflammation by means of the cautery. The best treatment for active inflammatory ulcers is to apply trichloracetic acid (15- to 25-per-cent solution) every third or fourth day. If the ulcer is one that spreads rapidly and will not yield to solutions of nitrate of silver or strong bichloride of mercury or even trichloracetic acid, it should be gently curetted, and the actual cautery applied to its base to destroy the infected tissue. Such a procedure seems hazardous, but its value can be readily understood when it is remembered that most of the infected tissue is thereby destroyed, and, besides, its stimulating action causes an excess of lymph to flow from the vessels, extending in the direction of the ulcer, thus limiting the infective, disintegrating process to a greater or less extent. The operation, singularly enough, is absolutely free from pain. Enzymol (50 per cent), locally applied to these ulcers, seems to be productive of great benefit.

When perforation threatens, paracentesis should be performed at once. This relaxes the corneal fibres by permitting the escape of the aqueous humour. The operation is performed by inserting a broad needle, or keratone, into the corneal tissue near its lower margin directly into the anterior chamber. Removal of the aqueous humour is facilitated by gently twisting the keratone within the wound, thus enlarging its opening. The Sæmisch operation, which consists in dividing the ulcer into halves horizontally, the incision extending through the corneal tissue at both extremities, is sometimes employed and is of great value in selected cases.

The general health of the patient must be carefully looked after, and improved as much as possible.

Both eyes should be tightly bandaged to insure the greatest amount of rest possible.

Prognosis.—As can be readily seen from the history and course of this affection, the ultimate result depends entirely upon whether perforation has or has not taken place. In non-perforative ulcers appropriate treatment is attended by amazing results, but in the other variety irreparable damage is usually produced.

ULCERS OF THE CORNEA

Ulceration of the cornea is always a terminal stage of some inflammatory disease of that structure, resulting in its molecular death and regeneration by scar tissue. In the early stage the cornea is clouded as a result of a dense aggregation of leucocytes, which takes a prominent part in inflammatory reaction. As the condition progresses the exudate is either thrown off, leaving a shallow base, or is retained as an abscess of the cornea, either of which terminations may be followed by perforation depending upon the intensity of the inflammation, the nutrition of the cornea, the character of the treatment, etc. The final stage is characterized by the filling up of the ulceration by connective tissue which may embed the iris or other prolapsed tissue, but regeneration of the cornea never occurs except in the most superficial cases. The new-formed scar tissue being more dense than the corneal tissue, offers great obstruction to perfect vision.

In all corneal ulcerations the pathology is much the same, but owing to the innumerable circumstances that may modify their course, duration, and manifestations, it is customary to describe several distinct clinical varieties. The principal varieties are considered only as regards the differences in the appearances they present, and are discussed under separate headings. Corneal ulcers may arise without obvious cause, but upon careful inquiry and examination they may be traced to injury, impaired nutrition, infection, or extension from adjacent inflammations. The injury that may induce these changes varies greatly in extent and character, and is usually associated with the introduction of micro-organisms. Ulceration from impaired nutrition may follow undue exposure, as in trigeminal palsy, lagophthalmos, exophthalmos, facial paralysis, and deformities of the lids; but here also the exciting cause is some form or combination of micro-organisms. Xerotic keratitis belongs to this class, and occurs in greatly debilitated children. The ulceration is attended by no active inflammatory symptoms. Infection of a wounded corneal surface by the staphylococcus, streptococcus, pneumococcus, diphtheria bacillus, tubercle bacillus, aspergillus fumigatus, etc., may induce any form of corneal ulceration, but is more marked in the serpiginous form and in abscess of the cornea. The infectious fevers, such as small-pox, scarlet fever, measles, typhoid, typhus, pyæmia, etc., may induce ulceration by their local lesions attacking the cornea, by malnutrition, or by the presence of bacteria or their poisons in the blood. As examples of corneal ulcers due to extension may be mentioned those occurring in phlyctenular disease and purulent inflammation of the conjunctiva and other ocular structures.

Ulcerative inflammations may involve a portion of all the epithelium, Bowman's membrane, or the cornea propria. The membrane of Descemet does not seem liable to ulceration, but will burst when exposed by loss of corneal tissue.

Simple Ulcer.—A small grayish spot located at the corneoscleral margin of the cornea. It appears as a small phlyctenule (blister) or a "gouged-out" depression in the substance of epithelial and Bowman's membrane. These ulcers are of various sizes, scarcely ever larger than a millet-seed. The "comet-shaped" ulcer progresses rapidly, eating its way across the cornea, not over two or three millimetres in width, followed in its train by new-formed blood-vessels. In the simple ulcers pus is never present, but pain, photophobia, and lacrymation may or may not occur. The progressive character of the simple ulcer shows itself by the nebulous colour of its edges.

Causes.—In infants it is due to alterations in nutrition, dentition, or the mild eruptive fevers.

Treatment.—Locally, mydriatics are employed to dilate the pupil and to place the eye at rest. An ointment containing the yellow oxide of mercury (⅛ grain to 1 dram), together with a solution of nitrate of silver (1 grain to 1 ounce), is of great value. The dusting of levigated calomel once daily is a useful

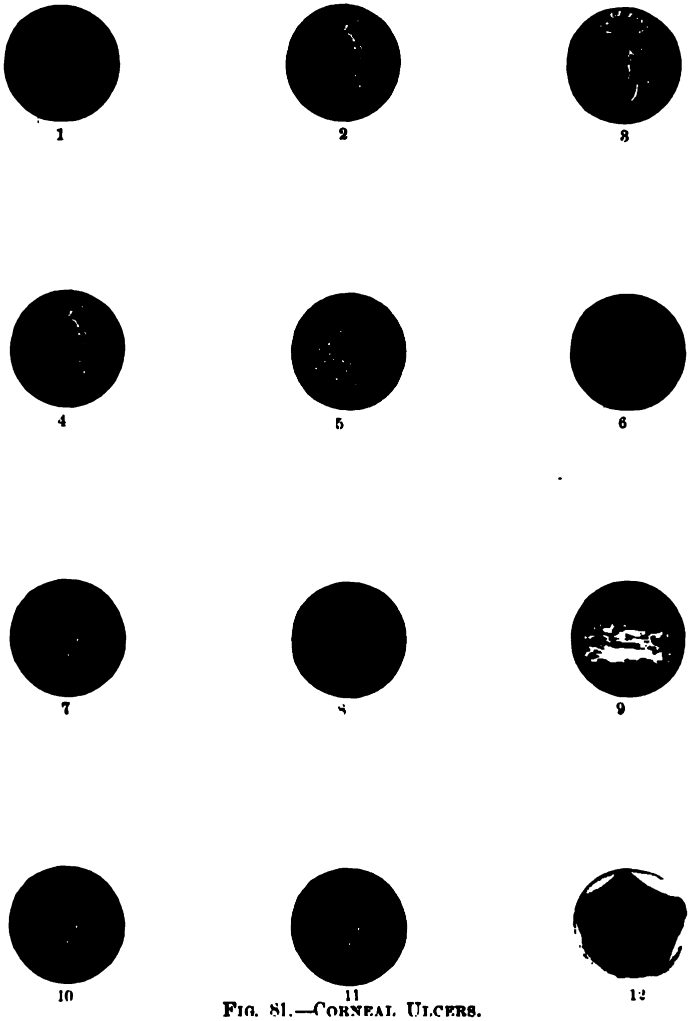


FIG. 81.—CORNEAL ULCERS.

1, 2, 3, 4, Herpes cornea (Horner); 5, keratitis punctata superficialis; 6, keratitis punctata; 7, keratitis traumatica; 8, 9, ribbon-shaped keratitis; 10, 11, comet-shaped ulcer; 12, marginal keratitis.

adjunct to the remedies just mentioned, all of which are much used and are efficacious. In the more intractable and superficial ulcers the author has found subconjunctival injections of saline infusion of great value, especially those that have resisted the action of mercury.

℞	Sodii saccharat.	gr. xv;
	Aq. destil	℥j.

M. S. for subconjunctival injection.

In the superficial ulcers with an invasion of blood-vessels running over the cornea scarification at the corneo-scleral margin or a partial peritomy is valuable; this should be followed by the use of the following formula:

℞	Daturine sulph.	gr. ½;
	Acidi boracici	gr. vj;
	Acidi carbolic	♏j;
	Aq. destil.	℥j.

M. Sig.: Five drops in the eye four times daily.

Internally—Fowler's solution of the arsenite of potassium and the syrup of the iodide of iron, in small doses, should be administered three times daily. Good nourishing food and hot salt baths at night should not be forgotten.

Infected Ulcers.—The simple ulcer may become the focus of infectious inflammation from bacteria, which find lodgment in this area and invade the tissue of the cornea, giving rise to a breaking down in width and depth, causing either a staphyloma or prolapse of the iris ultimately.

Serpiginous or Sæmisch Ulcer.—This ulceration is a very obstinate and troublesome form of the infectious variety. It has a curved and wavy margin and yellow base, showing a tendency to spread over the surface of the cornea unattended by vessels of repair, leaving in its path infiltrations of pus or broken-down corneal tissue. Hypopyon is almost always present, and iritis is likely to occur as a complication. Perforation is sure to take place in this form of ulcer if allowed to progress.

Treatment.—Applications of trichloracetic acid (10- to 20-per-cent solution) and iodine vasogen (6- to 10-per-cent solution) should be made to the ulcer. If the ulcer does not yield to the above treatment, then a Sæmisch operation must be performed.

Purulent Ulcer.—These are usually the outcome of an injury, and are very common among farmers and those following the mechanical trades, such as stone-cutters, masons, etc. The author has seen many cases in which farmers, while thrashing, were struck in the eye by flying grains of wheat, causing the cornea to be bruised, and followed by the loss of the eye. The same condition is found when the eye is struck by a small piece of stone. A sharp bit of steel in penetrating the cornea rarely produces ulceration; it is only when the fragment has been removed or an attempt has been made to remove it by a mechanic in the shop with a blunt point of a pen-knife or tooth-pick that infection follows.

Treatment.—The treatment of the different varieties of infected or purulent ulcers is essentially the same. A mydriatic should be applied once or twice daily; this dilates the iris and puts the ciliary body at rest, as well as depletes the blood-vessels. The eye should be thoroughly douched with an antiseptic wash, in which the following drugs are used, either singly or in combination: boric acid, zinc chloride, sulphocarbolate of zinc, and sulphate of hydrastin.

The direct application of nitrate of silver, in solid stick or strong solution (10 to 20 grains to the fluid ounce), is also advised; even the actual cautery may have to be employed. Dr. Alexander Duane advocates iodine-vasogen instead of tincture iodine or carbolic acid.

The trichloracetic acid application (10- to 25-per-cent solution), once daily, as advised by Dr. D. H. Coover, is most valuable. It is necessary to anæsthetize the eye before using this drug. Hot fomentations of poppy-heads are used to relieve this intense pain; they should be applied frequently during the day. The eye should be bandaged to prevent the eyelids from irritating the ulcer.

Sequelæ.—When there has been more or less destruction of the corneal tissue, leucoma of a more or less pronounced type may be expected. The location of these opacities in the cornea determines the loss, or at least interference, of vision. A central leucoma may render the eye blind for practical purposes, vision being obtained only when mydriasis is produced. If iritic complications are present, loss of vision may be produced by the adhesions formed or by the glaucoma that may develop. If the cornea alone has been attacked, anterior staphyloma may follow.

Hypopyon.—This condition is characterized by an accumulation of pus at the bottom of the anterior chamber. It is usually dependent upon an abscess or suppurating ulcer of the cornea, or upon some process or suppuration involving the iris, ciliary body, retina, or choroid, etc. The quantity of pus in the chamber varies; sometimes it is hardly perceptible, while at other times it may nearly fill the chamber. It presents a yellowish hue when viewed through the clear cornea.

Onyx.—The accumulation of pus between the corneal lamina is termed onyx. It can generally be distinguished from hypopyon by the irregular limits of the pus deposit. If the pus in hypopyon is fluid enough, movements of the head will cause it to move also, making a fluid-level, and in such a case the diagnosis is at once established. Focal illumination will generally serve to distinguish these conditions, although they may sometimes co-exist.

Treatment.—The cause should be attacked as early as possible, its removal being followed by the rapid disappearance of the pus. It is sometimes necessary to perform an incision in the lower third of the cornea (Sæmisch) with a Von Graefe knife, to the extent of one-half of its diameter, to evacuate the pus, which should never be evacuated if the hypopyon is due to irido-cyclitis, or suppurating chorio-retinitis, as long as there is an opportunity of saving the eyeball from panophthalmitis by intense medication. The onyx will disappear after the local application of hot fomentations and yellow oxide-of-mercury ointment and the internal administration of gray powders, 2 grains three or four times daily. Leeches may be applied to the temple to relieve the pain.

Chandler of Boston and Risley of Philadelphia report favourably on the use of cassaripe (the inspissated juice of the cassava, a tropical plant) in ointment (10 per cent) in the treatment of corneal ulcers and infective inflammations, such as purulent ophthalmia. Although highly antiseptic, it is devoid of irritating properties and may be freely rubbed into the conjunctival folds two or three times daily. Irrigation by means of boric-acid lotion and the application of a pressure bandage in corneal affections increases its good results materially.

Traumatic Ulcers.—Traumatic ulcers should be treated antiseptically as soon as possible after the injury has been received They become, as a rule, infected by the foreign body, if it is allowed to remain in the wound and neglected. After the foreign body is removed, it is well to irrigate the eye with a solution of boric acid. Atropine drops should be instilled at once, even if the patient is fifty years of age or older, and the eye bandaged with an iced pad.

Frequently a scratch from a finger-nail or a bruise of the cornea by a foreign body that does not become lodged in it, produces an ulcer. When these accidents occur, the treatment already described should be immediately instituted. Interference with the vision will depend on the location of the injury; if it is on the margin of the cornea, the sight will not be noticeably interfered with; the more nearly it approaches the centre the greater will be the interference.

If the ulcer is seen several days after the injury and pus has developed or hypopyon made its appearance, the application of iodine-vasogen (10 per cent) or a 20-per-cent solution of trichlor-acetic acid is most beneficial, and their good effects become manifest after three or four applications. When trichloracetic acid is first applied to the ulcer the spot becomes white, like coagulated albumin, and the pain, for a few minutes, is very severe; therefore cocaine should always be applied first. In twenty-four hours, however, the cornea will assume a healthy appearance, the ulcer will have become clearer, and the pus, if any is present, will disappear with greater rapidity than under any other treatment that the author has tried.

A patient recently came under my care with a cornea which had been punctured by a table-fork, an infected wound being the result. The case was first seen thirty-six hours after the accident. The corneal puncture was distinctly outlined by a circle of infiltration; pus was present in the layers of the cornea; there was marked hypopyon; the iris was contracted, and apparently infiltrated, and iritis was developing. The case was a desperate one, and loss of the eye seemed inevitable. A 5-per-cent solution of cocaine was first instilled to mitigate the pain of the acid application, and after several minutes had elapsed the puncture was touched with a 25-per-cent solution of the trichloracetic acid. The condition of the cornea after the application was rather startling; the spot and its adjacent vicinity turned as white as the albumin of a boiled egg. Atropine was than instilled, the eye bandaged, and the pad kept saturated with a special lotion. At the end of twenty-four hours the cornea was clear, the zone of pus infiltration had materially lessened, and there was a marked decrease of the hypopyon. After three applications (25, 15, 10 per cent successively) of the acid the pus had entirely disappeared and the iris cleared up, the eyeball was saved, and useful vision restored.

Dendritic or Branching Ulcer (*Keratitis Dendritica*).—This variety of ulcer has been so named on account of its peculiar shape, not unlike the figure seen in the moss agate or shrubs observed in fossils.

It is slow in progress, being rarely found active in inflammatory reaction, but when such is the case it is attended by photophobia, lacrymation, œdema of the upper lids, denuded epithelium over the track of the ulcer, etc. It is seen in young people of low vitality and in older individuals of irregular habits and depleted constitutions.

The cause is still unknown, although it is believed that a micro-organism is responsible for its development.

Treatment.—Internally, strong mineral tonics and nourishing food. Locally, a few drops of an eye-lotion, containing chloride of zinc (2 grains to the ounce of distilled water), should be instilled three times daily, and 1 or 2 drops of a solution of scopalamine hydrobromate should be used to dilate the pupil. Iodine-vasogen (6 to 10 per cent) or iodoform vasogen (3 per cent) is also efficacious.

Malarial Ulcer.—This form of ulcer occasionally occurs in persons who are or were the sufferers of malaria. The ulcer has no characteristic shape, in some cases being round, in others irregular, and in still others developing into branches much resembling the dendritic ulcer. The symptoms are similar to those given under the heading of suppurative ulcer.

Treatment.—The administration of quinine and arsenic internally will cause it to disappear.

Locally, the following formula is advised:

℞ Hydrastin sulph. .... gr. ij;
Aq. menth. pip............................ ʒiij;
Aq. camph., }
Aq. destil. } ....āā ℥ij.
M. Sig.: Bathe eyes freely three times daily.

In all forms of corneal ulceration, when a drop of a solution of fluorescein is applied, the outline of the ulcer is at once distinguished by the green tint which the ulcerative surface assumes.

Fluorescein, 3 grains; natr. carbonic, 5 grains; aq. destil., 3 drams, is the formula employed.

The less frequent forms of corneal ulceration are the rodent ulcer, the marginal ring ulcer, the transparent ulcer, and the mycotic ulcer due to infection by the aspergillus fumigatus.

Keratitis bullosa is an uncommon form of corneal inflammation which occurs as a symptom of irido-cyclitis, interstitial keratitis, or glaucoma, and is characterized by vesicles and blebs on the corneal surface. It has occurred in the course of malaria, but is most frequent in connection with ocular diseases. The true nature of the affection is unknown.

The symptoms include pain, photophobia, lacrymation, pericorneal injection, and the eruption of the vesicles and blebs which tend to rupture, leaving behind abrasions and ulcerations of the cornea. Relapses are frequent and the symptoms are markedly exaggerated with each outbreak of the lesions.

The treatment consists in the free administration of tonics and stimulants, particularly quinine, especially if malaria is suspected. Locally, puncture of the blebs should be performed, after which the bases should be treated as ordinary corneal ulcers. The attendant ocular inflammation should receive appropriate treatment according to its character. Operative procedures, such as enucleation and iridectomy, may be necessary.

Ribbon keratitis is a trophic degeneration of the anterior layers of the cornea, characterized by thickening and roughening of the corneal surface, with its subsequent cloudiness. The opacification becomes more marked, and seems to be due to the deposition of calcareous plaques. The disease is most frequent in eyes that have undergone retrograde changes as the result of glaucoma, iritis, etc. Mild irritative symptoms are present and considerable alteration in vision is produced. Treatment is of no avail.

Keratitis punctata is not a true corneal inflammation, but consists merely in the deposition of opaque material in the form of spots on the posterior elastic lamina or membrane of Descemet. They are usually triangular in arrangement, with the apex towards the pupillary margins. This condition is always secondary to some disease of the iris, choroid, or vitreous, and is described in connection with these affections.

The cornea often presents pathological changes in diseases of the other portions of the eye independent of any distinct disease of its structure. Of these the most important occur in glaucoma, in which disease uniform steaminess and anæsthesia of the cornea are particularly characteristic.

The presence of a foreign body on the cornea is also attended by infiltration and pericorneal injection near the site of the foreign particle.

HERPES CORNEÆ FEBRILIS (HORNER)

Herpes corneæ is the term applied to herpes zoster of the ophthalmic nerve attacking the cornea, and should not be confounded with keratitis herpetiea or keratitis bullosa.

It is also applied to a herpetic condition of the cornea which occurs in disturbances of the respiratory tract, as in influenza, pneumonia, laryngitis, tracheo-bronchitis, etc. It develops very rapidly, making its appearance after the fever of the above-mentioned diseases has disappeared. It may or it may not be associated with herpes facialis or herpes labialis. This form of ulcer is without pain, but very intractable, usually lasting from four to twelve weeks. The corneal epithelium is the only membrane attacked; in this respect, the disease resembles an attack of herpes facialis or labialis, as in the latter disease the cuticle (epidermis) exfoliates, leaving a raw surface of the true skin. The absence of pain indicates a neuro-paralytic affection. The exfoliation of the epithelium vesicles develops very rapidly. In one or two days a chain of vesicles appear, break down, resembling the denuded surface of the cornea after the removal of a foreign body by unskilful hands.

This plaque may remain without change for two weeks or more excepting a slight haziness of the surface; suddenly another area around the original ulceration may show desquamation, and this spot may rest quietly for two weeks, when again another outbreak may occur, until the whole of the epithelial layer is attacked. A drop of fluorescin solution aids materially in outlining the ulcer by giving the denuded surface a markedly green discoloration. An outbreak of the disease is usually preceded by conjunctivitis, coryza, and some pericorneal injection of the conjunctival blood-vessels which might easily be overlooked until after the ulcer had made its appearance. There is little or no pain, but slight inability to raise the eyelid. The complications arising may be suppurative keratitis, hypopyon, and iritis.

Treatment.—This should be local and constitutional. A mydriatic should be instilled to dilate the iris and put the eye at rest. Trichloracetic acid (10-per-cent solution) and tincture iodine are the best local remedies. After the ulcer has been outlined by the fluorescin solution, this area should be touched with either the acid or iodine on a cotton swab. Two drops of cocaine or holocaine should be instilled in the eye five minutes before the applications are made, as sometimes considerable pain is caused by these drugs, especially the acid. The applications should be repeated every second day until improvement is noted. The eye should be irrigated with a hydrastin, boric acid, or 1-to-5,000 sublimate solution, three times daily, and should be kept bandaged. In very painful ulcers ol. ricini, dropped into the eye, gives great relief.

℞ Ol. ricini .... ʒiij.
Ol. rosæ ....q. s.
M.

Sig.: One drop in the eye every half hour until relief is obtained.

The nasal cavities should be examined and sprayed with an antiseptic wash. Then constitutional treatment should always be carried out: elixir of iron, quinine, and strychnine, mercury, etc., should be administered to maintain the general health.

Prognosis.—The ultimate disturbance of vision is in inverse proportion to the degree of normal restoration of epithelium.

CORNEAL OPACITIES

A faint haziness of the cornea, the result of a previous inflammatory process, is known as a *nebula*. A spot of greater opacity, and of decidedly gray colour, is called a *macula*. A mass of cicatricial tissue, of a decidedly white hue and not transmitting light, receives the name of *leucoma*.

Treatment.—A nebula resulting from recent ulcers may be largely cleared up by the application of an ointment composed of oil of turpentine, gtt. xx, and vaseline, dram 1. Yellow oxide of mercury is also recommended, and electricity is said to be beneficial (Alleman). In cases of central nebula an iridectomy performed behind a transparent portion of the cornea may be considered for the purpose of improving vision. If anterior synechiæ are present, they should be severed if any trouble arises from their presence. In certain forms of haziness and opacities of the cornea the author has had encouraging results from the use of massage, injections of salt solutions, and thiosinamine.

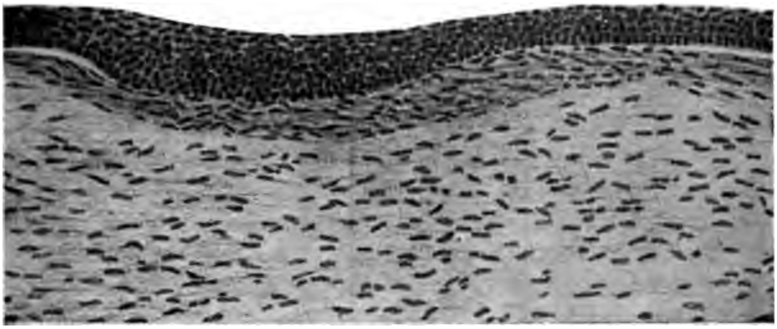


FIG. 82.—LEUCOMA OF THE CORNEA. (Magnus.)

Transplantation of a rabbit's cornea has also been attempted by Von Hipple, and that of a chicken by the author, in cases where vision was destroyed by corneal opacity, but the results were not satisfactory, the transferred cornea becoming shrunken and opaque. Von Hipple's method consisted in making a circular incision in the cornea by means of an especially constructed trephine, after which the leucomatous material was carefully dis-

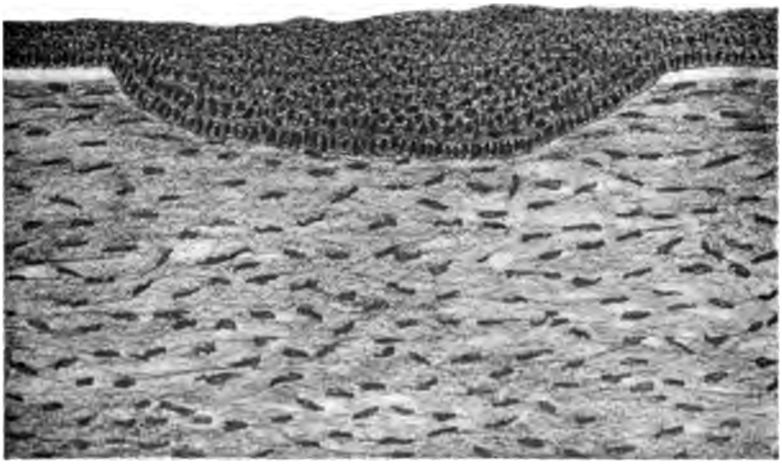


FIG. 83.—EPITHELIAL CICATRIX OF THE CORNEA. (Magnus.)

sected from the membrane of Descemet. A portion of the animal's cornea is removed by the trephine and gently inserted upon the human cornea. The eye is then bandaged.

Tattooing of the cornea.—When the operation is demanded by the patient from a purely cosmetic standpoint, tattooing yields very good results, even if the nebula is extensive. This operation was first introduced into ophthalmic surgery by Abadie and De Wecker, of Paris, and may be successfully employed if the opacity of the cornea is permanent. If the cornea is very thin or the operation is likely to bring about intraocular irritation, tattooing is contra-indicated. For detailed operation and literature upon tattooing, see article by J. Hirschberg, Deutsche med. Wochenschr., 1891.

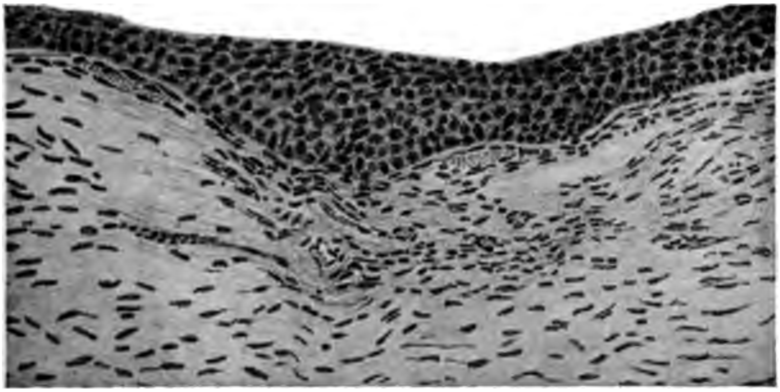


FIG. 84.—RECENT CICATRIX OF THE CORNEA. (Magnus.)

Sepia ink, in stick form, is used in the operation, a piece of the india ink being rubbed down with water into a thick paste, and then pricked into the cornea, which has been previously anæsthetized by the local application of cocaine. The best instrument for this purpose is a collection of four needles held together in a handle. The ink is placed on the cornea with a small spatula, and each impression of the instrument makes four pricks. The pricks should be numerous and the cornea *vigorously fanned* during the entire operation so that the ink will dry rapidly. It is also necessary to prevent the tears from collecting in the conjunctival *cul-de-sac*; if this occurs, they should be drained off with cotton. Both eyes are bandaged after the operation for twenty-four hours to prevent motion, at the end of which time the corneal epithelium has covered the scar and the pigment is thus protected. In a few exceptional cases the operation is repeated to tone and round out the area of tattooing.

TUMOURS

Tumours of the cornea may be either benign or malignant. To the former class belong dermoid and other cysts; to the latter carcinoma, melano-sarcoma, and epithelioma—the last being the most common. Benign tumours may be removed with little danger of return. In the malignant forms it is frequently necessary to include the orbital contents in the operation.

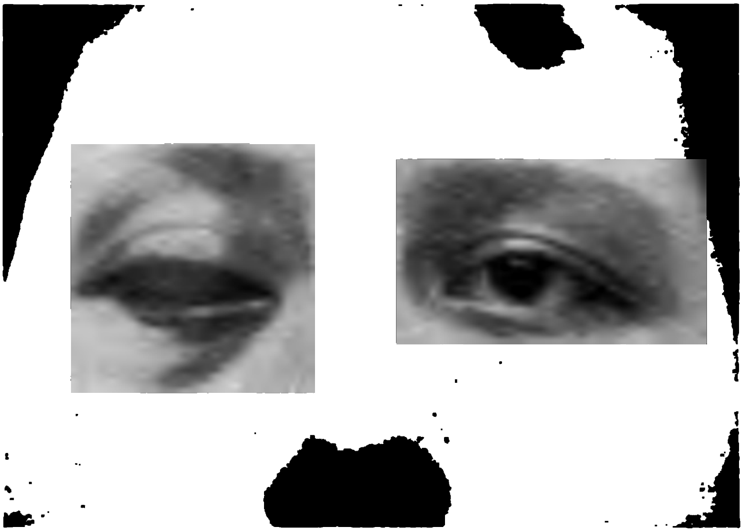


FIG. 85.—CONGENITAL ALBUGO OCULORUM.

FOREIGN BODIES

Foreign bodies lodging in the cornea provoke an irritation, but pain is produced only when the cornea comes in contact with the conjunctiva of the eyelid. The object should be removed as quickly as possible under cocaine by means of a cotton swab or spud and the wound treated according to antiseptic principles. Boric-acid lotion and similar sedative solutions should be employed.

ARCUS SENILIS

Senile zone.

A fatty degeneration of the margin of the cornea presenting a slight diminution in the translucency of its texture and assuming by degrees a similar shape. There is, however, in many instances, a curvilinear interspace of clear cornea through which the iris may be seen. The opacity may vary from a thin line to 1 to 2 millimetres in width, and in rare instances even wider. It rarely makes its appearance before the age of fifty, and is one of the physical signs of fatty infiltration. Professor da Costa, years ago, called attention in his lectures to this sign as associated with fatty infiltration of the heart, muscles, etc. The author has seen this opacity in very young people, but this was, no doubt, a remnant of embryonic arrest of development of the cornea and not a true disease.

According to Edward Canton, F. R. C. S., the cornea may be attacked by ulceration at the site of the senile zone, which follows ordinarily the upper segment. This ulceration, according to this author, when associated with *arcus senilis*, is usually found in persons who are gouty or rheumatic, or who have led irregular lives. The author has never encountered an ulceration of this character. In dark eyes, the opacity is more pronounced than in gray ones.

An arcus senilis does not interfere with the healing of corneal incisions in cataract operations.

ANOMALIES IN THE CURVATURE OF THE CORNEA

Conical cornea—Keratoconus.

A conical protrusion of the cornea anteriorly due to increased intraocular pressure and thinning of its central portion. The sugar-loaf appearance or conical distention of the cornea may be easily seen when the disease reaches a certain degree of development. The front of the eye has a peculiarly brilliant and sparkling appearance, and sometimes resembles a drop of clear water upon a convex glass surface. Viewed in profile, owing to the double refraction of light, the cornea appears dark between the apex and the base of the cone. When the eye is examined in a darkened room by means of the ophthalmoscope, one sees an interrupted wavy reflex instead of a clear red one. The point of light and shadow revolves around the base of the cone. This annular shadow is particularly characteristic, and attention was first called to it by Sir William Bowman.

Ætiology.—The true cause is unknown, but in all probability it results from atrophic processes in the *cornea propria,* together with an increase in intraocular pressure inducing the bulging outward of the cornea.

Progress and Termination.—The disease usually makes its appearance from the fifteenth to the twentieth year, and is more common in females than males, particularly in those who are debilitated. The first symptoms are referable to the gradual loss of vision, which may remain stationary and again in a short time become more pronounced. Before visual acuity becomes diminished the patient will complain greatly of multiple vision, or *polyopia monocularis.* The disease often attacks both eyes successively, and yet the author has obtained two cases in which but one eye was affected. The progressive myopia causes the condition to be easily confounded with true myopia, and is only distinguished by the results of an ophthalmoscopic examination or when trial lenses are used to improve the vision.

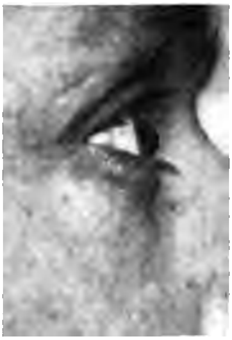


FIG. 86.—CONICAL CORNEA.

Diagnosis.—It may be confused with the distention of the cornea following keratitis, hernia of the cornea, partial staphyloma and true staphyloma, all of which show more or less deposition of inflammatory products, whereas the cornea is clear in keratoconus.

Treatment.—Internal medication is useless, it being impossible to restore the cornea to its natural form. Operative measures are sometimes employed. Various operations have been suggested, among which may be mentioned the evacuation of the aqueous; removing a V-shaped piece from the cone and suturing the opening, removing a transparent crystalline lens (Adams); causing ulceration of the corneal apex by applying the solid stick of nitrate of silver (Von Graefe); applying the electro-cautery to the apex of the cone (Sir Anderson Critchett), and the making of an artificial pupil (Tyrrell). Every operator has had some success with these procedures in flattening the cornea, but in all of these many operations considerable risk must be assumed. Tyrrell's method consists in making a puncture through the cornea with a small keratome close to the sclerotic, and then drawing out a small portion of the iris to bring the pupil from behind the apex of the cone. The iris is held in place by the cicatrizing wound. The author has had improvement in vision follow a small iridectomy and sclerotomy in quite a few cases. The majority of American patients hesitate considerably before accepting the risk incident to any of the above operations named, preferring in most cases to bear the yoke of semi-blindness.

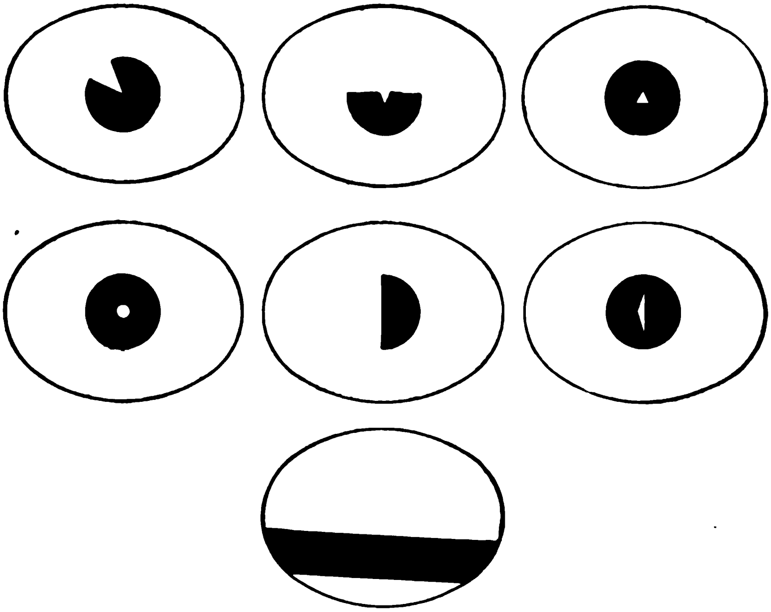


Fig. 87.—Opaque Slips for Lenses in Treatment of Conical Cornea.

Great benefit can be accomplished by cylindrical lenses (hyperbolic glasses) in improving vision. These have the disadvantage that in movements of the head the centres of the lenses fail to correspond to the pupillary centres, and their neutralizing effect is destroyed. Contact glasses have been suggested by the French ophthalmic surgeons, but proof is wanting as regards to their practical efficiency. In one case under the observation of the author, in which the removal of an elliptical portion of the cone afforded some benefit, marked improvement was produced by a method suggested by the author and carried out in detail by the patient. A series of experiments extending over a period of several years were performed in an effort to adapt some form of disk that would permit rays of light to enter the eye through the least refractive portion of the cornea. The investigation began with a pinhole disk and stenopaic slit, and included the testing of every form of prism and patch until a satisfactory result was obtained. The conclusions reached were as follows:

1. That the character of the disk and its angle vary in each case.
2. That the intelligence of the patient is an indispensable adjunct in the selection of the necessary disk, as the method is almost entirely subjective.
3. That lenses in which the corneal area is screened by black patches of various sizes and shapes containing the requisite slits are better adapted for this purpose, and are less noticeable than prisms or ground glasses.
4. That the refraction of the cornea varies from time to time, requiring frequent examinations with changing of the disks.
5. That the incorporation of the patches with the correcting lenses gives rise to an additional improvement.
6. That the only disadvantage lies in the fact that the patches do not correspond to the cornea during ocular movement, but this is compensated for by the marked improvement and comfort afforded when the eyes and disks are adjusted for some average range.
7. That a fair trial should be made with these disks before resorting to operative procedure.

In other cases this method has been employed with very gratifying results, but in this particular case vision was brought to $\frac{6}{9}$ and $\frac{6}{12}$, and work at close range was comparatively easy when a disk with a smaller aperture was employed.

The quotation, in part, of this patient's letter describing this procedure is as follows:

"Of these small black opaque disks I find the one with the round opening to serve my purpose best, for distance as well as for reading, when used in front of the left eye. To this particular disk I have devoted much time and attention, having experimented with a number of different sized openings—round and otherwise—in order to find the 'happy medium' for all needs and requirements, and I know I have found it in this size. It serves me well on plane glass, and remarkably well when used in connection with the 9 D concave cylinders. So much for the left eye.

"Now, as regards the right or near-sighted eye of mine, I obtain the best results for this eye with the half-disk which has the small V cut into the centre of same, for reading purposes, and at the same time answers quite well for distance, but then only in twilight and not otherwise. As you will notice, this latter, or V-shape, is a part of and has the same dimensions as the 'triangle' disk, and to which I have also given a great deal of attention and experimented with various sizes before finally deciding on this as being the best for the purpose—reading—and which I find especially so when used in conjunction with the 9 D cylinders.

"As to the remainder of the disks, they all have their special merits, though the above mentioned seem to be about the best, and as near perfection for my case as I believe it is possible to get them, and I must confess I am very well satisfied with the results thus far obtained, and sincerely hope that they may yet be the means of benefiting others equally as much as they have myself through your efforts in this direction."

GLOBULAR CORNEA

Keratoblobus, Anterior Hydrophthalmia, Buphthalmos, the Eye of Juno.

A general spherical distention of the cornea—a rare form of dropsy of the anterior chamber. The iris and cornea are enlarged, but the tension and fundus appearance are normal. Hyperopia is present and visual acuity is normal. It may simulate infantile glaucoma, but careful examination will serve to make a distinction.

Treatment.—Sclerotomy and repeated paracentesis are suggested.

Keratectasia.—The term applied to the undue protrusion of an opaque cornea as the result of some inflammatory condition unattended by perforation. The iris remains unaffected, thus distinguishing the condition from a staphyloma of the cornea.

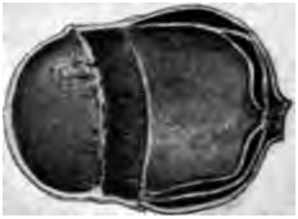


FIG. 88.—SECTION OF GLOBULAR CORNEA.

Staphyloma.—Is a protrusion of the eyeball anteriorly or posteriorly as the result of weakening of its structures. Anterior staphyloma usually consists in protrusion of an opaque cornea, together with the iris or the sclera alone. It most often follows gonorrhœal conjunctivitis.

Treatment.—Three modes of treatment suggest themselves in the following order: 1, sclerotomy; 2, Critchett's ablation; 3, enucleation.

Blood pigment is occasionally deposited in the layers of the cornea around the sclero-corneal margin, causing it to assume a brownish colour. This condition is most frequently observed

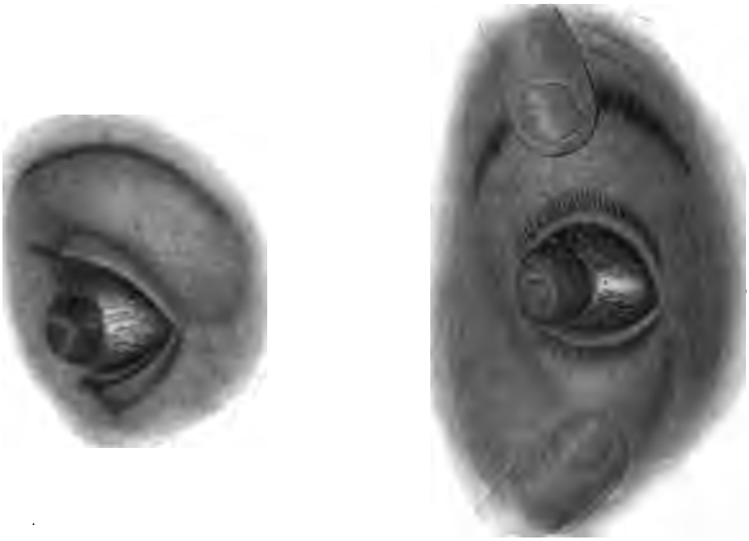


FIG. 89.—STAPHYLOMA OF CORNEA.

after hæmorrhage into the anterior or posterior chambers. The blood is carried by the minute lymph-streams to the cornea, where it is broken up into its component parts. This disintegration requires a period of from one to four weeks, after which the pigmentation undergoes very gradual absorption.

CHAPTER VII

DISEASES OF THE SCLERA

The sclera or external coat of the eye is not as liable to disease processes as the other portions of the eye. Its tough, fibrous structure and the scarcity of blood-vessels seem to protect it from acute inflammation particularly. The loose connective tissue that separates it from the conjunctiva and capsule of Tenon is known as the episcleral tissue, and is comparatively rich in blood-vessels, being thus predisposed, to a certain extent, to inflammatory conditions. Disease limited to the sclera alone is not common, it being more frequent to find such conditions associated with morbid affections of adjacent ocular structures.

The principal affections to which the sclera is liable are inflammation, staphyloma, and injuries.

SCLERITIS

Inflammation of the sclera may be either superficial or deep, according to the structure involved. Superficial scleral inflammation is limited to the episcleral tissue, and is known as episcleritis.

Episcleritis, or inflammation of the subconjunctival connective tissue, consists usually of a circumscribed inflammatory area upon the sclera with or without any accompanying deep inflammation.

Causes.—Episcleritis may arise as a secondary affection, and in such cases it is usually associated with inflammation of the anterior segment of the eye. Under these circumstances it is often impossible to distinguish it from the causal condition. Occurring as a primary affection, episcleritis may in most cases be traced to some constitutional affection, such as gout, rheumatism, and syphilis. The condition seldom attacks children, being restricted almost entirely to adults. It is somewhat rare in this country. In the Medico-Chirurgical Hospital service the proportion is about 1 to 3,000, while at Moorfield's Eye Hospital, London, the proportion is about 1 to 700 (author's statistics). The frequency with which it attacks women is rather interesting, as most of these patients are nursing mothers or are the subjects of some uterine affection. A satisfactory explanation of this observation has not as yet been advanced. Episcleritis is also said to arise from digestive disturbances, disturbances of muscle-equilibrium, and eye-strain.

Symptoms.—The most prominent symptom is the well-defined area of reddish-violet or purplish hyperæmia of the swollen episcleral tissue due to injection of the ciliary, deep pericorneal, and conjunctival vessels. This peculiar congestion shows a marked tendency to extend around the corneo-scleral margin.

It usually involves but one eye at a time, and runs a very chronic course, extending over a period of four to eight weeks or more, although a fugacious form has been described by Fuchs that lasts but a few days and recurs at regular periods. Both eyes may become the subject of this disease, but an interval of one or two years usually elapses between the attacks in each eye.

The affected spot is always decidedly prominent, and its peculiar purplish discoloration is particularly characteristic. There is tenderness to touch and more or less constant pain and discomfort in the eye. The iris is always discoloured and sluggish, although no iritis is demonstrable. Photophobia and lacrymation may be present. The pressure of very small areas of episcleral inflammation may be mistaken for phlyctenules, but the vesicular character and ulcerative tendency of the latter will aid greatly in making a distinction. The eye affected by this disease is usually incapacitated for near work. The course of the average case of episcleritis is subacute, reaching its height in the course of three or four weeks, but the swelling and purplish discoloration may persist for several months. Relapses and recurrences are not uncommon.

Treatment.—In those cases in which the presence of a particular constitutional affection is obvious, the appropriate medication should be prescribed, pushed to the point of tolerance. Often, for various reasons, it is impossible to elicit information or to detect symptoms concerning these disturbances, and in these patients the administration of mercury and chalk, salicylates, or iodides, alone or combined, is advisable. The salicylate and iodide of strontium have been well recommended in this condition.

Diaphoresis and free purgation should never be neglected as routine measures, as they are productive of no harm, and often give rise to considerable benefit. The administration of the alkalies in addition is a very useful procedure. The following formula has been employed by me in this condition over a period of several years with most excellent results:

℞ Sodii hyposulphit.	ʒiij;
Tinct. zingiberis	ʒijss;
Aq. chloroformi	℥ij;
Aq. anethi	℥viij.

M. Sig.: Tablespoonful after each meal.

The late Shadford Walker, F. R. C. S., Liverpool, England, suggested and used extensively in episcleritis in females the following formula:

℞ Decoction aloes comp.	℥ij;
Elixir ferri comp.	℥viij.

(Griffith's iron mixture.)

M.

Sig.: Tablespoonful in water three times daily, after meals.

This formula has also given me most gratifying results. My attention was first called to it by Mr. T. Herbert Bickerton, the successor and former assistant of Mr. Walker.

The local treatment consists in the application of sedative eye-lotions. Massage of the eyeball through the lids with the ointment of the yellow oxide of mercury should also be employed. Scarification of the swelling and scraping of the tissues to the healthy sclerotic is a radical measure, but is most efficacious. Leeching of the temple by means of the Heurteloup leech should be performed in order to relieve the attendant pain. Atropine (1 grain to the ounce) should be instilled to place the iris and ciliary body at rest. It also serves to lessen any tendency towards corneal involvement.

Prognosis.—The disease is very obstinate to treatment and quite frequently recurs after a cure has apparently been effected. As a sequel of the disease there may be atrophied areas of the sclera, especially around the corneo-scleral margin. The inflammation may extend to the cornea, producing slight opacities, or may even cause blindness by extensive corneal opacities. The iris and ciliary bodies may also become involved, and give rise to an irido-cyclitis.

Scleritis.—Deep inflammation of the sclera is known as scleritis, and affects the external layers, together with the subconjunctival tissues. It may be accompanied by kerato-iritis.

Causes.—The condition is generally observed in adults, and is most commonly met with in gouty or rheumatic individuals. It may also be associated with syphilis, disturbed menstruation, and exposure to cold. Scleritis frequently occurs in mothers, due to lactation; this would seem to indicate a relation between the disease and a disturbance of the general nutrition.

A knowledge of this fact is of great value in planning the treatment, which is essentially tonic in character.

Symptoms.—A faint purplish tint is observed in the sclerotic, owing to the general injection of the superficial vessels. The sclerotic becomes deeper in colour as the inflammation progresses, and at the same time assumes a bluish-red tint. There is lacrymation and photophobia; both eyes may be involved. The inflammation is more diffused than in episcleritis, and may extend around the entire corneal margin. There is marked impairment of vision.

Progress and Termination.—The disease usually lasts several weeks, but may be of still longer duration if the affection involves different parts of the sclerotic. After absorption of the inflammatory products the injection becomes pale, and the affected part becomes grayish in colour. This gray colour is due to the chorioidal pigment shining through the sclera, which in severe inflammations becomes very much thinned. The corneal opacities disappear, becoming permanent only in rare cases.

Pain is not a marked symptom in the majority of cases, but it may exist and assume a neuralgic character, especially when the ciliary bodies become involved. Vision is only affected when the disease is complicated by keratitis, iritis, or chorioiditis.

Diagnosis.—It is distinguished from phlyctenular conjunctivitis by the deeper red of the hyperæmia, and by its chronic course. From keratitis and iritis it is diagnosed by the absence of changes in the cornea or iris, except in those cases in which it is complicated by sclerosing keratitis.

Treatment.—The eyes should be bathed frequently with hot water in which poppy-heads have been steeped, and atropine should be instilled. The eyes should be rested, and protected from the light by dark glasses or a bandage. Massage during the acute hyperæmia has been found to be of great benefit. Caustics are always contra-indicated; instead, mild astringent lotions should be applied to soothe the eyes.

If there is a strumous diathesis or a history of syphilis, gout, or rheumatism, the treatment should be instituted accordingly.

Prognosis.—The inflammation may extend to the deeper coats of the eye, causing intraocular lesions, with consequent impairment of vision. The prognosis, however, is rather favourable in the majority of cases.

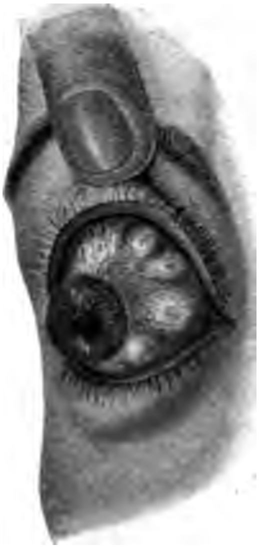


FIG. 90.—STAPHYLOMATA OF SCLERA.

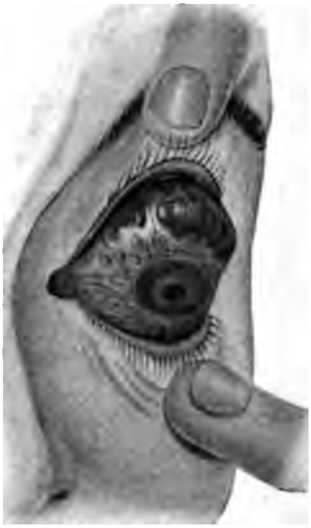


FIG. 91.—STAPHYLOMATA OF SCLERA.

Corneal infiltration, with inflammation of the uveal tract, is apt to follow chronic scleritis, and anterior staphyloma may occur as a result of the weakening of the corneal fibres. When the cornea is extensively implicated, the prognosis is much less favourable.

STAPHYLOMA OF THE SCLERA

Staphyloma of the sclera may be either anterior or posterior; the former may be a sequel of scleritis or episcleritis, while the latter is usually associated with myopia and chorioiditis; it is also said to be hereditary. In anterior staphyloma the sclera assumes a bluish tint, which is due to the fact that the dark pigmented ciliary body or chorioid shows through the attenuated sclerotic. Equatorial staphyloma may also occur from the same causes.

An iridectomy or sclerotomy in the early stages of anterior staphyloma will check the disease. If there is no glaucoma, mydriatics are useful. If the staphyloma is pronounced and vision has been entirely lost, the eye should be enucleated.

In posterior staphyloma the eye must not be used for work that causes eye-strain, and proper glasses should be prescribed.

BUPHTHALMOS

SYNONYMS: *The eye of Juno; Hydrophthalmos; Congenital glaucoma.*

This condition, which is generally observed in childhood, usually depends on a congenital failure of the angle of the anterior chamber to open, as it does in the course of normal development. This causes increased tension, which, in the developing eye, results in a gradual distention of all its coats. It may also be secondary to glaucoma.

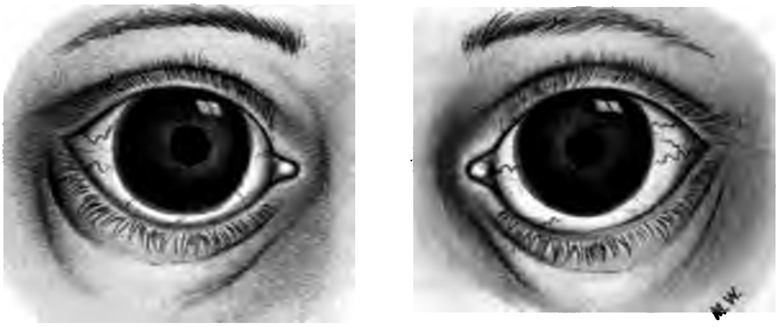
The globe is enlarged in all its diameters; the cornea becomes very prominent, comprising about one-third of the outer tunic. The sclera has a bluish tint on account of its thinning. The lens remains small and is loosely attached; the optic disk becomes cupped and gradually deteriorates; the anterior chamber is deep and filled with aqueous fluid; and the diameter of the iris is much beyond the normal.

Diminution of vision, nystagmus, pain, and photophobia are symptoms accompanying this condition.

Treatment.—Prolonged use of a myotic (eserine, ½ grain to 3 drams) may assist in retarding the disease, but as it only gives temporary relief, a sclerotomy or iridectomy should be performed as soon as possible. The prognosis is not favourable, and parents must be warned as to the ultimate loss of vision.

INJURIES TO THE SCLERA

The sclera is subject to incised, lacerated, and punctured wounds, all of which may be infected or non-infected in character. Non-infected wounds are the least dangerous, and heal rapidly.



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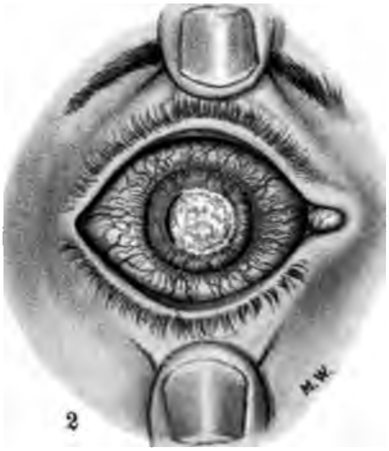

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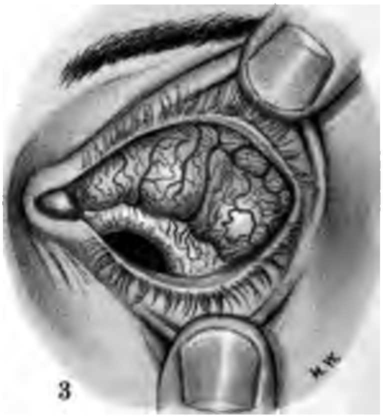

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PLATE II.—RARE OCULAR CONDITIONS.

(Drawn by **Margaretta Washington.**)

Buphthalmos—eye of Juno. (Author's case.)
Mycotic ulcer of cornea, due to aspergillus fumigatis. (Author's case.)
Fatty tumour of sclera involving anterior portion extending completely around the eyeball. (Author's case.)

Infected wounds, on the contrary, nearly always induce panophthalmitis. Although the sclera may be injured by traumatism applied in various ways, it usually receives its injury from the entrance of foreign bodies.

Foreign bodies which partially penetrate the sclerotic should at once be removed with delicate forceps. Small fragments of glass are the most difficult to remove, since they pass through the conjunctiva and find lodgment in the sclerotic. The only way to remove the glass, which is generally invisible, is to locate it by gentle pressure, grasp the conjunctiva, raise it, and cut out conjunctiva and episcleral tissue with curved scissors. This sometimes is all that is necessary; if the glass is buried in the sclerotic it can then be taken out with delicate forceps. Foreign bodies that escape the ordinary methods for their detection may be located by the X-ray, or the magnet in the case of metallic particles.

In cuts of the sclerotic, with escape of the vitreous, it is best to cut off the band of vitreous and apply a pressure bandage; or, if the wound is very extensive, ½ to 1 centimetre of the conjunctiva and episcleral tissue may be drawn together by a suture.

Rupture of the sclerotic from a blow is always serious, not only on account of the wound to the sclerotic, but also on account of the danger to the chorioid, and the possibility of intra-ocular hæmorrhages. In cases of this character the eyeball should be removed.

In all scleral injuries, the wound should be freely irrigated and antisepticized by boric-acid solution (10 grains to the ounce) or bichloride-of-mercury solution (1 to 5,000), and a firm pressure bandage applied. Rest in bed should be advised, if practicable. Iced compresses should be employed to reduce any inflammatory action. In wounds of the sclera alone, in which there are clean wound margins, sutures may be introduced.

Among the very rare morbid conditions of the sclera may be mentioned abscess, ulcer, gumma, tubercle, fibroma, sarcoma, enchondroma, and pigmentation of the sclera.

CHAPTER VIII

DISEASES OF THE IRIS AND CILIARY BODY

Introduction.—The iris and ciliary body form the anterior portion of the uveal tract or vascular coat of the eye, the remaining portion being formed by the chorioid. The close connection of these structures is such that when one portion is diseased the remaining portions are liable to participate in the morbid process. The function of the iris and ciliary bodies depends largely upon their vascular structure, and this latter predisposes towards inflammatory conditions. Inflammation is the most common affection, and is attended by enormous dilatation of the vessels in the affected and adjacent structures and is manifested externally by the peculiar deep ciliary injection. The functional activity of the iris and the ciliary body is suspended and the colour of the iris becomes changed. During the progress of this affection adhesions form upon the posterior surface of the cornea or anterior surface of the lens which, if left intact, greatly limit the motion of the iris, and change the shape and size of the pupil. These adhesions are known as synechiæ. A somewhat similar condition is produced during fœtal life by the presence of a thin transparent membrane. This is known as the pupillary membrane and normally disappears by absorption about the seventh or eighth fœtal month, and is of importance in determining the age of infants prematurely born. It may occasionally persist after birth.

CONGENITAL ANOMALIES

Pigment alterations are comparatively frequent. The iris pigment may be grouped or scattered throughout each iris or the tints may differ. *Heterochromia* is the term applied when the colour of one iris is normally different from that of the other iris. A difference in colour may also follow diseased conditions of this structure. An absence or marked diminution in pigment is observed in albinos, in whom the iris appears pink, due to the reflex of the fundus shining through it.

Alterations in position are rather common and deserve passing notice. An eccentric position of the pupil downward and to the inner side is normal, but this may be markedly exaggerated, and is then known as *corectopia* or *ectopia pupillæ*. It may be symmetrical, and is sometimes seen in several members of the same family.

Absence of the Iris.—Ideræmia or aniridia is a very rare congenital defect. In this condition, which is frequently hereditary, the iris may be partially or completely absent in both eyes. Nystagmus, dimness of vision, photophobia, and opacities of the cornea are common accompaniments.

Multiplicity of the pupils or **polycoria** is an ophthalmological curiosity. It is seen most frequently as the result of traumatism. In these cases only one of the openings responds to light or is influenced by drugs.

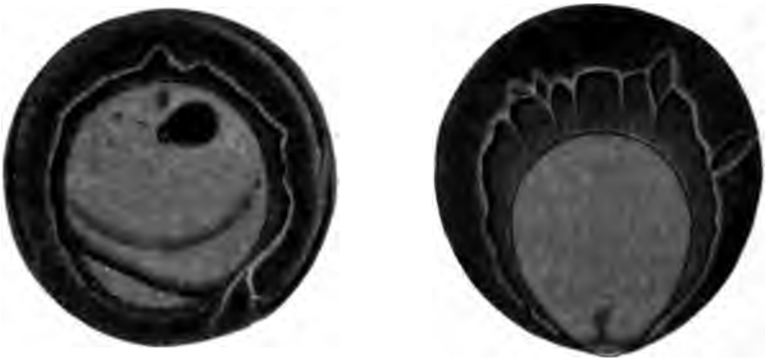

FIG. 92.—COLOBOMA OF THE IRIS.

Persistent pupillary membrane is occasionally encountered. It is manifested by the presence of opaque threads stretched across the pupil. It is usually unilateral, and the true nature of the condition may be detected by oblique illumination.

Coloboma is a cleft or fissure of the iris extending downward and inward and resembling an imperfect iridectomy; unless exceptionally extensive it does not interfere materially with vision. It may be associated with coloboma of the ciliary body or chorioid; it is usually monocular.

Growths. — The vascular structure of the iris predisposes towards the overdevelopment of certain portions of it, resulting in nævi, congenital cysts, etc., but the occurrence of these growths is very rare.

Functional Disorders of the Iris.—The most frequent functional disorders of the iris are *mydriasis, myosis,* and *hippus.* These have been described at length in the chapter on The Pupil in Health and Disease, to which the reader is referred.

Iridodonesis.—The most frequent cause of iridodonesis or tremulous iris is the total absence of the lens, or its partial or complete dislocation. In some cases the condition is congenital. In cases due to luxation of the lens the iris oscillates when the eye is moved in different directions; when the lens is only partially dislocated the tremulousness will be confined to that portion of the iris which has lost the support of the lens. The condition is also observed in those cases in which the anterior chamber of the eye is enlarged and the iris is stretched sidewise, the support of the lens thus being lost.

Hyperæmia of the Iris.—Congestion of the iris always precedes iritis, but in addition it may be associated with inflammation of neighbouring structures, as in conjunctivitis, keratitis, scleritis, traumatic conditions, etc. It is characterized by a change in the colour of the iris; usually it changes to green or reddish brown, according to the original colour of the iris. The deep pericorneal vessels are enlarged coincidently. The pupil is contracted, and its reaction to light and accommodation is extremely sluggish. Synechiæ do not form in simple hyperæmia, and resolution occurs unless inflammation follows.

Treatment.—The instillation of atropine in addition to the measures indicated to combat the causal affection usually suffices to bring about the normal condition of the iris.

Iritis.—Inflammation of the iris is the most frequent affection to which this structure is liable, and is always preceded by hyperæmia.

Causes.—It may arise as a symptomatic affection in the course of syphilis, gout, rheumatism, diabetes, tuberculosis, etc., or it may occur as the result of extension of inflammation from adjacent ocular structures. It is also due to traumatism, exposure to cold and wet, febrile diseases, new growths, etc. Dental caries has also been recorded as a causal factor in iritis. The disease is sometimes encountered as an idiopathic affection.

Symptoms.—The manifestations of iritis may be considered as objective and subjective. These vary more or less according to the character and intensity of the inflammation, but on the whole are rather constant.

The objective phenomena are mostly referable to the changes in the iris itself, and include alterations in its colour, similar to those seen in hyperæmia, but exaggerated in intensity; contraction with sluggish and irregular movements of the pupil; adhesion of the iris to the lens capsule as demonstrated by the instillation of atropine; together with punctate deposits on the posterior layer of the cornea, changes in the aqueous humour and anterior chamber, including turbidity, hypopyon, hyphæmia, and fibrinous exudates. The depth of the anterior chamber may be greater than normal and the intraocular tension may be increased. Externally, there is present marked pericorneal injection involving the deeper ciliary vessels. There is also conjunctival congestion, but this is more superficial and movable than the pink zone of iritis.

The subjective symptoms include neuralgic pain distributed over the course of the fifth cranial nerve, and worse at night; more or less tenderness on palpation over the ciliary region; photophobia, lacrymation, tiring of accommodation, diminution in the acuity of vision, malaise, fever, nausea, etc.

Varieties.—According to its course, iritis may be divided into acute, subacute, and chronic. Acute cases require several weeks to complete their course, but recurrences are frequent and the affection is likely to become chronic. One or both eyes may be attacked; usually the disease begins in the second eye when it is subsiding in the first.

Iritis may also be classified, according to its pathology, as simple or plastic, serous, and parenchymatous or purulent.

Simple or plastic iritis is the most frequent form of the affection encountered. It is characterized by marked ciliary and pericorneal congestion; slight œdema of the subconjunctival tissue; haziness of the aqueous; discoloration of the iris; contraction and immobility of the pupil; and adhesions of the iris to the lens capsule. The pupil seems to be rolled under, and this appearance is best seen by the aid of a corneal microscope. This type of the disease is also distinguished by the pouring out of the exudate into the pupillary space, forming a false membrane in that area. Occasionally the exudate consolidates and is deposited as a gelatinous mass in the bottom of the anterior chamber.

Causes.—In from 30 to 60 per cent of cases this affection can be directly traced to acquired syphilis. Of the remaining cases a large number are attributed to extension of inflammation of the cornea, sclera, ciliary body, chorioid, etc. Injury, infectious fevers, rheumatism, etc., are also causes. It may occur without obvious cause.

Course.—It may be acute, subacute, or chronic. A case may be acute and run its course within a few weeks with total absorption of the exudate and complete return to normal. Such cases are rare, however, and the most frequent termination is the leaving behind of adhesion or opacities upon the anterior lens capsule. As a primary result vision is always impaired, but more serious consequences may follow the changing of these adhesions into contracting connective-tissue bands. These adhesions not only serve to limit the movements of the pupil, but are a source of constant irritation, tending to induce recurrences upon the most trivial cause. Total occlusion of the pupil or total synechiæ may be produced, and as an ultimate result secondary glaucoma and blindness may occur.

Treatment.—As the most frequent constitutional disturbances inducing this disorder are syphilis and rheumatism, the general treatment should be directed towards either or both affections, as they frequently exist combined. Mercury should also be employed to its physiological limit for its antiphlogistic effect.

The local treatment is of utmost importance, as the danger of the disease lies in the formation of adhesions, and these can readily be prevented by prompt and appropriate local measures.

Atropine (4 grains to the ounce) should be instilled every three hours until mydriasis is complete, after which it may be employed less frequently. This procedure not only dilates the pupil, but places the ciliary muscle at rest and relieves the pain in part. Leeching of the temple by means of Heurteloup leech or leeches diminishes the congestion and lessens the pain considerably. The application of hot moist compresses has an additional anodyne effect.

Subconjunctival injections of corrosive sublimate, etc., have been recommended by various ophthalmologists. The injection of salt solutions combined with the ordinary treatment seems to be singularly effective in my experience, but the manner in which its effect is brought about is not clear. The following abstract in London Lancet, April 4, 1903, of an address delivered by Dr. Karl Wessely to the Natural History Society of Carlsbad, is of interest in this connection:

Dr. Wessely's experiments with subconjunctival injections of salt solutions were made upon rabbits, and the results were carefully observed. He concludes that these injections do not act through their osmotic power upon the internal humours of the eye, since analyses have proved that their penetrating power is very small, that they do not produce their effect as lymphagogues, nor so far as regards sodium-chloride injections by any direct action in setting free leucocytes. They really act by powerful local stimuli to the conjunctiva, and even when frequently employed have no injurious effects. The nerves of the conjunctiva thus energetically stimulated act in a reflex manner, presumably through the vaso-motor nerves in the vessels of the adjoining vascular territory, leading to dilatation of the ciliary area. The hyperæmic condition of the ciliary vessels renders their walls more permeable, and the result is the secretion of aqueous humor containing much albumin, in place of the normal aqueous, which contains none. Dr. Wessely then passes to a consideration of the therapeutic value of these injections, and observes incidentally that the accompanying processes of inflammation, particularly œdema, have long been regarded as safeguards to the organism without any particular reasons. Bacteriological researches have, however, shown that the serum of normal blood contains several protective materials which play an important part in the strife against the lower organisms, and that these materials, to which the names of *bacteriolysin, agglutinin, hemolysin,* and *percipitin* have been applied, are in all probability associated with the albumin of the serum. The question immediately arose whether as the normal aqueous humor is almost destitute of albumin, while that secreted after subconjunctival injections contained a notable proportion of albumin, the beneficial effects observed might be due to the presence of ferments, enzymes, or solvents eliminated with it. Experiments made with animals rendered immune with the blood of an ox showed that the normal aqueous humor has no power of dissolving bovine blood-corpuscles, and hence contains no hæmolysin. But if a subconjunctival injection were made of a 5- to 10-per-cent solution of common salt, and after the lapse of half an hour the aqueous was withdrawn, it quickly dissolved an equal volume of a 5-per-cent mixture of blood-corpuscles—a very interesting result—and still other experiments demonstrated clearly that the power of solution in the newly secreted aqueous was in direct proportion to the amount of albumin that the fluid contained.

Serous iritis is characterized by a serous exudation which manifests itself chiefly as deposits of various sizes on the membrane of Descemet and on the capsule of the lens. These deposits take the form of opaque dots on the posterior layer of the cornea and are arranged in the shape of a triangle with its apex pointing upward, constituting the condition known as *keratitis punctata.* There is slight pericorneal injection and the cornea and aqueous humor are somewhat hazy. The anterior chamber is deeper than normal and the pupil is semi-dilated and immobile. In the early stages the intraocular tension is likely to be high, but approaches normal as the case progresses. There is very little supraorbital pain and slight tendency towards the formation of adhesions. It is frequently associated with a serous inflammation of the ciliary body. *Descemetitis* and *Aquo-capsulitis* are other terms often employed to designate serous iritis.

Causes.—The affection is probably most often encountered in association with other ocular inflammations, particularly the early stages of sympathetic ophthalmia. It also occurs as a manifestation of some constitutional affection, such as syphilis, gout, rheumatism, anæmia, etc., and in these cases is bilateral. It is observed with great frequency in women with uterine affections.

Symptoms.—The manifestations of serous iritis have already been given in the description of the disease. The diagnostic feature, however, is the punctate deposits upon the membrane of Descemet. The course of the affection is extremely chronic and there are no signs of active inflammation. The affection is often prolonged by involvement of other portions of the uveal tract, a not uncommon occurrence.

Treatment.—Usually the depressed state of the patient calls for free administration of tonics, such as alcohol, strychnine, iron, quinine, etc., and an extremely nourishing diet. Mercury, although indicated on account of the presence of some syphilitic taint, should be withheld temporarily in many cases on account of its depressing effect. Free purgation, diaphoresis, and diuresis are to be employed routinely. The internal administration of iodide of potassium or iodide of iron will aid in the absorption of the inflammatory products. Locally, atropine should be instilled, but not so frequently as in plastic iritis. An increase of tension indicates paracentesis of the cornea, but if this procedure fails to relieve it, resort to an iridectomy may be necessary.

Parenchymatous or suppurative iritis is characterized by marked cellular proliferation within its tissues, causing the iris to assume a swollen or nodular appearance. When localized, small yellowish nodules may be seen in the membrane, but when generalized the entire iris is swollen and discoloured yellow and the margin of the pupil is bound down to the capsule of the lens. The congestion is so intense that frequently by the aid of a convex lens it is possible to distinguish the vessels of the iris. Occasionally these vessels rupture and there is an extravasation of blood in the anterior chamber. A more common occurrence is the deposition of pus-cells from a purulent effusion in the parenchyma of the iris, in the anterior chamber constituting *hypopyon*. This purulent exudate in the anterior chamber is fluid in character and changes its position with the movements of the head, thus distinguishing it from the hypopyon that attends *ulcus serpens* of the cornea. It is freely absorbed, and its duration, therefore, may be but twenty-four or forty-eight hours. Recently a case came under the author's observation in which the entire anterior chamber was filled with pus and caused the cornea to appear as if infiltrated. The lids were swollen and œdematous, and there was great occipital pain. Distortion of the pupil is a constant accompaniment of this form of iritis.

Causes.—The later stages of syphilis are frequently manifested by parenchymatous inflammation of the iris. This may be indicated by the formation of one or more yellowish or reddish-brown nodules in the iris tissue situated at either the pupillary or ciliary border. The inflammatory changes are distinctly localized to these nodules, the intervening tissue being unaffected. No scarring is left behind after their absorption, but pigment may remain. This condition may be considered as of the papular type of syphilis. Gumma of the iris is less frequent and is always a solitary nodule. It appears with greatest frequency at the ciliary border and rapidly breaks down and discharges its contents, to be replaced by connective tissue. Syphilis is also responsible for some cases of diffuse parenchymatous iritis.

Tuberculosis may also be manifested by tubercles in the parenchyma of the iris. This is extremely rare. In such cases, however, the nodules are of a pale-yellow colour and situated at some distance from the edge of the iris in its lower half. These nodules occur in groups, and there is associated with them tubercular changes in the adjacent lymphatic glands. There are no symptoms of acute inflammation, and hypopyon is seldom if ever seen. Young persons in whom other tubercular manifestations may be detected are most frequently attacked.

Diabetes is also responsible for a certain number of cases of parenchymatous iritis, particularly those intractable forms that occasionally follow cataract extraction. Gonorrhœa and rheumatism have been observed to induce this form of iritis.

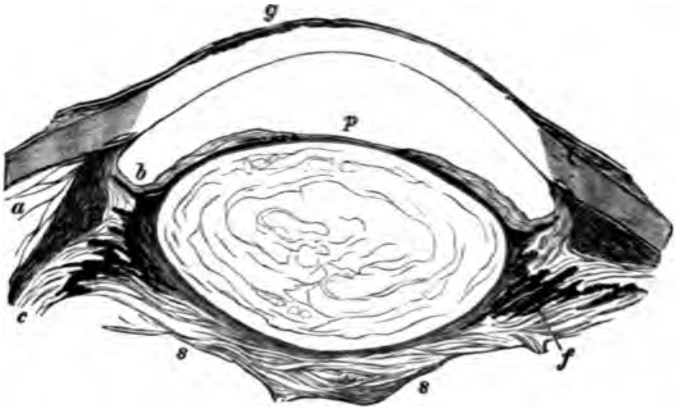

Fig. 93.—Total Posterior Synechia. Vertical Section through the Eye. Magnified 5 × 1.

The iris is adherent by its posterior surface to the anterior capsule of the lens and also to the anterior surface of the ciliary body. The posterior chamber consequently is obliterated and the anterior chamber deepened at its periphery, *b*; at this spot the iris is strongly retracted and at the same time is here the most thinned through atrophy. The exudate connecting the iris with the lens also stretches as a thin membrane, *p*, across the pupil. The hull of exudate, *s*, springing from the ciliary body, envelops the posterior surface of the lens and by its shrinking draws the ciliary processes towards the centre. As a result of this, a separation of the ciliary body, *c*, from its bed has already taken place below, and in the intermediate space are seen the disjoined lamellæ of the suprachorioid membrane, *a*. The pigment epithelium, *f*, of the ciliary processes has undergone proliferation. At the lower part of the cornea there is a zonular opacity, *g*. The lens is swollen and is opaque throughout; there is no hard, undisintegrated nucleus (i. e., it is a soft cataract).

The infectious fevers, such as septicæmia, pyæmia, malaria, typhoid fever, influenza, etc., are occasionally attended by parenchymatous iritis and hypopyon due to infection of the iris by their respective bacteria through the blood-stream.

Perhaps the most common cause of parenchymatous iritis is local infection of the iris. This may occur in the course of unclean surgical operations upon the eye, or it may be due to traumatism or the entrance of foreign bodies into the eyeball. It may also arise secondarily from perforation of a corneal ulcer.

Very rarely it may be impossible to attribute the affection to any cause.

Symptoms.—The principal symptoms and those of diagnostic importance are the swelling of the iris with the formation of nodules and the purulent exudate in the anterior chamber. The changes in the size, shape, and motility of the pupil are also of importance. The course varies according to the underlying cause.

Treatment.—In syphilitic cases the free use of mercury and the iodides hastens the absorption of the nodules. In this variety, as in tubercular iritis, tonics and stimulants should be employed to combat the attendant anæmia. Those cases due to diabetes require the usual dietetic and medicinal measures indicated in that disease. Infected cases may be prevented to a great degree by extreme asepsis during operations and by avoiding operation in cases associated with lacrymal or other adjacent purulent affections. Locally atropine should be instilled in order to prevent adhesions and to place the ciliary body at rest. Frequent irrigation is necessary in infected cases.

Diagnosis.—Iritis may be confused with simple conjunctivitis, phlyctenular conjunctivitis, keratitis, and acute glaucoma. In differentiating these affections it is of the utmost importance to consider in detail the condition of every portion of the eye. The presence of superficial or deep congestion of the conjunctiva, the transparency and sensation of the cornea, the depth of the anterior chamber, the colour of the iris, the reaction of the pupil to light accommodation and convergence, the condition of the media and fundus, and the tension should receive the most careful attention. In iritis, for instance, the conjunctiva is normal; there is a fine deep pericorneal injection forming an immovable pink zone around the cornea; triangular punctate deposit upon the lower half of the posterior layer of the cornea in some cases, but usually the cornea retains its normal condition in simple cases; normal depth of the anterior chamber unless accompanied by complications; hypopyon in purulent iritis; the iris is always discoloured, as may be ascertained by comparison with its fellow; the pupil is small and reacts to light very sluggishly, if at all, and upon the instillation of a mydriatic becomes markedly irregular, showing the presence of adhesions; the eyeground and media are unaltered in uncomplicated cases; and the tension is normal in most cases. In addition there will be neuralgic pain, worse at night, tenderness over the ciliary region, and gradual diminution in vision, but no contraction of the visual field.

In simple conjunctivitis, the inflammation is limited to the conjunctiva, the vessels of that structure are enormously engorged, but pericorneal injection, Descemetitis, hypopyon, discoloration of the iris, changes in the size and motility of the pupil, synechiæ, and neuralgia are absent. There is considerable mucopurulent discharge in conjunctivitis, and none at all in iritis.

In phlyctenular conjunctivitis the occurrence of the phlyctenules upon the cornea may give rise to pericorneal injection in addition to its other characteristic symptoms, but a careful examination will fail to detect any alterations in the iris and pupil, such as described under iritis.

Keratitis is characterized essentially by diffuse or localized cloudiness, but is unattended by ciliary tenderness, nocturnal neuralgia, or changes in the iris or pupil unless complicated by iritis.

In glaucoma the pain is severe, but not necessarily nocturnal; the conjunctival vessels are dark red in colour and widely dilated; the cornea is hazy and less sensitive than normal; the iris is discoloured; the pupil is dilated and sluggish and filled by a green reflex; the tension is enormously increased; the anterior chamber is shallow and the iris is in close contact with the cornea; there is sudden diminution of vision with contraction of the visual field, most marked towards the nasal side; and the characteristic cupping of the optic nerve. Atropine should never be instilled in these cases, as it serves to aggravate the condition.

Although these affections usually exist alone, they may be encountered combined and should be recognised promptly, as the treatment is materially altered in such cases. The occurrence of glaucoma in the course of iritis, for instance, often requires operative measures.

The distinction between the several varieties of iritis is not as important as at first glance would seem to indicate. However, if the occasion arises for such a differentiation, it may be made by remembering that adhesions of the iris to the lens are most marked in plastic iritis; that punctate keratitis is almost entirely limited to serous iritis; and that hypopyon and nodular formations in the iris are characteristic of parenchymatous iritis.

Treatment in all Forms of Iritis.—Owing to the difficulty in distinguishing the various forms of iritis and the danger of delay in waiting for the characteristic symptoms of each to develop, it is necessary to employ a mode of treatment applicable to all. A saline purgative should be administered at once to bring about depletion. Owing to the prominence of syphilis as an ætiologic factor, mercury should be administered until its physiologic limit is reached. The preparation of the drug is of minor importance, my own preference being for mercury and chalk (1 grain three times daily) and inunctions of mercurial ointment. The salicylate of strontium (5 to 10 grains three times daily), the wine of colchicum (10 drops every three hours until free purgative), aspirin, potassium iodide, quinine, and terebene may be administered in addition, particularly if there is any reason to suspect rheumatism as an underlying cause. Diabetes (Leber, Archiv. f. Ophthal., 1885) is in very rare cases a cause of iritis and should always be considered. In severe cases it will be necessary to place the patient at absolute rest in bed in a darkened room. The diet should not include nitrogenous foods or alcoholic stimulants. Free purgation by means of saline cathartics and diaphoresis by hot baths and the hypodermic injection of pilocarpine (¼ grain) are indicated.

Locally, mydriatics, such as atropine, duboisine, daturine, etc., should be instilled every three hours until the pupil is widely dilated. Adrenalin should be employed in combination with this mydriatic, and if conjunctivitis is present silver nitrate (5 grains to the ounce) may be applied. Subconjunctival salt injections should also be used. The application of leeches to the temple and venesection aid materially in lessening the severity of an attack. Hot fomentations of poppy-heads, applied over the circumorbital region, serve to relieve the pain to a considerable degree. In cases in which the iris is bound down to the lens capsule and ordinary medical treatment does not seem to modify the inflammation, an iridectomy, even when the disease is at its height, is advisable, and should be performed. The author has carried out this line of treatment in many serious cases with excellent results. The operation is performed in the usual manner, and iris being separated from the capsule with a Streatfeild ivory spatula. Sleep must be induced and the pain lessened by hypodermic injections of morphine.

In traumatic iritis the iris should be carefully replaced if prolapsed, in addition to the other measures recommended. If the prolapse is large, excision may be required.

Prognosis and Sequelæ.—An attack of mild iritis soon attains its height in a few days, runs an even course for ten days, and imperceptibly disappears at the end of three or four weeks. In the more severe forms the disease may be prolonged and extend over a number of months. A large percentage of cases when subjected to prompt treatment terminate favourably, leaving no traces of the former inflammation. Recurrences are frequent when synechiæ are left behind. In all forms of iritis there is coincident congestion of the ciliary body, but in the severe varieties actual cyclitis occurs, and is manifested by violent inflammatory symptoms, tenderness in the ciliary region, Descemetitis, etc. The entire uvea is also the seat of inflammation in some cases.

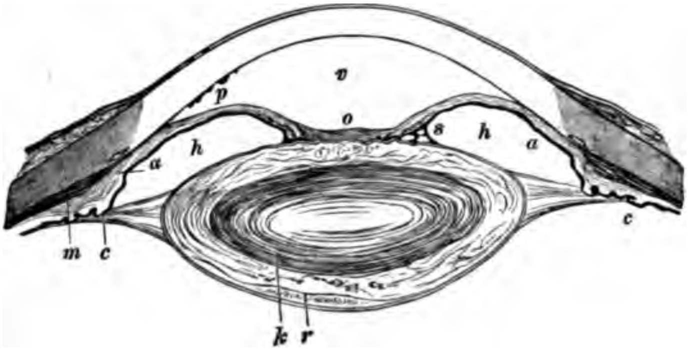

FIG. 94.—SECLUSION AND OCCLUSION OF THE PUPIL. Magnified 5 × 1.

The iris is adherent by its entire pupillary margin to the lens, but elsewhere is pushed forward. The posterior chamber, *h*, is thus made deeper, the anterior chamber, *v*, shallower, especially at the periphery where the root of the iris, *a*, is pressed against the cornea by the increase of tension. In consequence of the traction made upon the iris, its retinal pigment is beginning to separate (at *s*) and to be left upon the capsule of the lens. The pupil is closed by an exudate membrane, *o*, by the shrinking of which the anterior capsule is thrown into folds. In the lower part of the anterior chamber there is matter, *p*, precipitated upon the posterior surface of the cornea. In consequence of the increase in tension, both the ciliary processes, *c*, and the ciliary muscle, *m*, are atrophic and flattened. The cortex of the lens has undergone cataractous disintegration, and at *r* is separated from the capsule by liquor Morgagni; the nucleus, *k*, of the lens is unaltered.

Among the sequelæ may be mentioned anterior and posterior synechiæ, occlusion of the pupil, atrophy of the iris, deposits upon the anterior capsule of the lens, cataract, and vitreous opacities. In annual posterior synechia the pupillary margin is bound down by adhesions throughout its entire extent, giving rise to a condition known as *exclusion of the pupil.* The tension posterior to the iris causes it to bulge forward, producing *iris bombe.* Secondary glaucoma is liable to follow this condition, and unless relieved blindness will result.

Atrophy of the Iris.—Atrophy of a sector of the iris is an extremely rare condition, and consists in the entire absorption of the stroma and pigment, leaving behind nothing but the meshwork of the radiating and circular fibres. These thin fibres may be easily seen by the aid of the ophthalmoscope. In a case under my charge at the Medico-Chirurgical Hospital a quadrant of the iris was thus affected. The sector gradually changed from year to year, and the condition was evidently of neuroparalytic origin, as no history could be obtained as to its probable cause.

Atrophy of the iris also occurs as a sequel of inflammation of the iris.

Tumours of the Iris.—The lesions of tuberculosis and syphilis are probably most common morbid growths in the iris, but their descriptions are included under *parenchymatous iritis.*

Cysts occasionally form in the iris, and nearly always result from some form of traumatism to the iris. Their contents may be serous in character or semi-solid, due to the transplantation of epidermoid elements, such as an eyelash or a portion of the epidermis of the lid. They vary in size from very minute bodies to enormous enlargements that may fill the entire anterior chamber and induce glaucoma, irido-chorioiditis, or sympathetic ophthalmia by pressure. Cysts of the iris may be single or multiple, unilateral or bilateral. They are not malignant and are dangerous only by the pressure they occasion. Removal through a corneo-scleral wound is always indicated, and any adherent iris should also be removed by excision.

Granulomata sometimes occur in the iris and present the appearance of ordinary granulation tissue. Such growths are benign and of a pale colour. They enlarge gradually and eventually lead to rupture of the globe anteriorly with the production of phthisis bulbi. They are believed to be of syphilitic or tubercular origin. They should not be confused with the granulomatous condition of the iris that sometimes follows its prolapse. Excision of the growth is recommended.

Melanoma is a rather frequent condition and consists in an hypertrophy of hyperpigmented areas of the iris, and while usually benign and of no significance, it may be a precursor of sarcoma.

Sarcoma of the iris is a rare affection. Its occurrence as a primary growth is extremely rare. It may take place in the iris at first or it may involve the iris and ciliary body. The growth is pigmented in most cases and enlarges very gradually in the early stages, but later it increases rapidly in size, being attended by pain, hæmorrhage, etc. Eventually the globe is ruptured and a fungous-like mass protrudes. Metastasis soon takes place and death is a certain result. Removal of the growth when very small is indicated, but later enucleation of the eyeball will be necessary. The prognosis is always unfavourable. Secondary growths are usually found at a later period in the liver.

Non-pigmented sarcoma of the iris has been described, but is more rare than the melanotic form. It retains the malignant character common to all sarcomata.

Nævi occasionally present themselves in the iris owing to the vascular structure of that membrane. Operative interference is contra-indicated unless vision is greatly obstructed.

Leprosy may be attended by the deposition of the characteristic nodules in the iris. This is always rare, but is mostly observed in connection with leprosy of the face, in which the natural folds of the skin are markedly exaggerated and the face assumes the characteristic lion-like expression.

Ophthalmia nodosa is a chronic affection of the iris and conjunctiva, in which small hard nodules are found in those structures. It is extremely rare and is caused by the contact with an irritating substance contained within the hollow hairs of certain kinds of caterpillars. These hairs may be demonstrated in the nodules upon excision.

All growths of the iris tend to involve the ciliary body, and even the most benign are liable to be attended by dangerous symptoms by the pressure they occasion. The intraocular tension is always increased, and glaucoma, irido-cyclitis, and sympathetic ophthalmia are possible terminations in the most favourable cases.

Wounds of the Iris.—Traumatism applied to the globe of the eye may result in non-perforating or perforating wounds of the iris.

Non-perforating wounds are always due to concussion, such as induced by a blow upon the eye. They include traumatic mydriasis, rupture of the iris at its pupillary margin, and iridodialysis or separation of the iris from its ciliary attachment.

Traumatic mydriasis consists in permanent dilatation of the pupil, and results from paralysis of the sphincter at the pupillary margin. Eserine should be instilled in this condition.

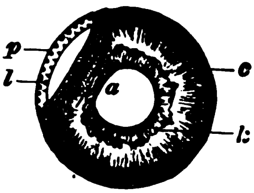

FIG. 95.—IRIDODIALYSIS. Magnified 2 × 1.

The pupillary margin at *a* is sloped off so as to form a straight line. At a point corresponding to this spot the iris is separated from the ciliary body and is narrower and somewhat wrinkled. In the interval between the iris and the margin of the cornea are seen the margin of the lens, *l*, and the apices of the ciliary processes, *p*: the fine radiating striation between the two structures represents the zonula of Zinn. *k*, circulus iridis minor; *c*, contraction furrows.

Rupture of the iris includes tearing of the pupillary margin and complete rupture of the sphincter of the iris. Mydriasis is present. In small lacerations it may be very difficult to detect the gaping. Atropine should first be instilled and followed later with eserine.

Iridodialysis, or rupture of the iris at its ciliary attachment, is characterized by the formation of an artificial pupil at the periphery through which the red reflex of the fundus shines. This is usually small and the artificial aperture is semilunar in shape, but in very rare instances the iris may be separated entirely from its ciliary attachment and be found lying in the bottom of the anterior chamber or under the conjunctiva after having escaped through a rent at the corneo-scleral margin. Complete detachment of the iris constitutes *traumatic aniridia*. Iridodialysis is always accompanied by more or less hæmorrhage into the anterior chamber, photophobia, and pain. The condition is usually incurable. A detached iris is always liable to displacement, and this occurs in two forms: *retroflexion*, in which the iris is folded back upon the ciliary processes, and *anteflexion*, in which it is twisted forward upon itself so as to expose to view its uveal surface. Complete displacement constitutes the condition already described as traumatic aniridia.

The treatment consists in the prolonged use of atropine, but unless the detachment is extremely small the likelihood of restoration to normal is small.

Perforating wounds of the iris include incised or penetrating wounds with or without the entrance and retention of foreign bodies. Perforating wounds seldom involve the iris alone, but injure the ciliary body and lens to a greater or less extent. An incised wound of the iris alone is not a serious condition and is repaired promptly. A frequent condition after perforating wounds of the anterior segment of the eye is prolapse or hernia through the cornea or sclera. In such cases efforts should be made to carefully replace the prolapsed portion, but if these are unsuccessful, excision is indicated. Strict antiseptic precautions should be observed in all these injuries. As already stated, wounds of the iris nearly always involve the ciliary body or lens or both. In the case of the ciliary body, inflammation or cyclitis is frequent, and the possibility of sympathetic ophthalmia should always be borne in mind. Involvement of the lens is always followed by an opacity of varying size, sometimes extending throughout the entire structure, constituting traumatic cataract.

The treatment in these cases consists first in placing the eye at rest by the instillation of atropine and cleansing it by frequent irrigation with warm boric-acid solution, and later in meeting the symptoms as they arise. Discission will be required for traumatic cataract, and enucleation will be indicated if sympathetic disease supervenes.

Perforating wounds of the iris induced by the entrance of foreign bodies deserves special consideration. There is always an additional element of danger from infection, particularly if the foreign body is retained.

Sometimes foreign bodies may become encysted in the parenchyma without exciting an irritation for a long time. Several years ago the author assisted Dr. Bickerton, of Liverpool, in the removal of a piece of glass from the anterior chamber of an eye which was driven through the cornea, the result of an explosion. The foreign body did not cause any irritation of the iris for a number of years.

Another interesting case occurred in the practice of the author in which a small piece of steel had been driven into the iris and was followed by no reaction. The foreign body became encysted, and several years afterward the patient presented himself for treatment, complaining of pain and dreading the occurrence of blindness. Examination at this time showed slight ciliary congestion. The colour of the affected iris was changed to a rusty gray, while the fellow iris retained its original light-gray colour. By means of a corneal microscope the foreign body was located by a slight elevation in the peripheral margin of the iris. It was subsequently removed by an iridectomy and relief of the symptoms followed. The microscopic examination of the excised portion revealed the presence of a partially oxidized piece of steel.

Treatment.—In all wounds of the eye cocaine should first be instilled in order to render subsequent examination and treatment painless. The eyeball and conjunctiva should then be irrigated by means of a warm boric-acid or bichloride-of-mercury solution. The presence of foreign bodies in the anterior chamber and iris are usually easily detected, and if metallic should be extracted through the wound of entrance by means of the magnet. If the foreign body is non-metallic, it may be removed by enlarging the original wound in the cornea or sclera and extracting it by means of a small pair of forceps. It must be remembered that an escape of blood into the anterior chamber follows nearly every wound of the iris and renders every examination difficult,so that operative interference should always be postponed until absorption takes place, which is usually a matter of but twenty-four or forty-eight hours. In all cases atropine should be frequently instilled and cold applications should be constantly made to combat inflammatory reaction.

Operations upon the Iris.—There are but two operations upon the iris: incision or iridotomy and excision or iridectomy.

Iridotomy consists in simply dividing the iris at a certain plane, and is most frequently employed for the production of an artificial pupil. Owing to the danger of wounding the lens in incision of the iris, the operation should be reserved for cases in which there is aphakia. The eye should be prepared and cocainized in the usual manner. A broad needle is then thrust through the cornea and iris 2 lines from the corneo-scleral margin, in a direction perpendicular to that of greatest tension. A De Wecker scissors is then introduced into the corneal incision, one blade passed into the anterior chamber and in front of the iris, while the second blade is passed into the vitreous, after which a horizontal cut is made by the scissors. Sometimes a V-shaped incision is made which allows contraction of the iris, and a larger pupil results.

Iridectomy, or excision of a portion of the iris, is indicated in glaucoma, in the combined operation for cataract extraction, in the formation of an artificial pupil, and in chronic iritis. The operation in glaucoma and cataract differ considerably, and are described in detail in the chapters on Glaucoma and Diseases of the Crystalline Lens (*q. v.*).

Iridectomy for the formation of an artificial pupil should always be performed directly back of a clear portion of the cornea. The keratome should be inserted about 1 millimetre behind the cornea, just where the scleral tissue seems to overlap it, and the incision is made long enough to afford sufficient room for withdrawing the iris, which is then cut off with one snip of De Wecker's scissors. Sometimes posterior synechiæ are present, and these should be first released by a Streatfeild ivory hook before withdrawing the iris.

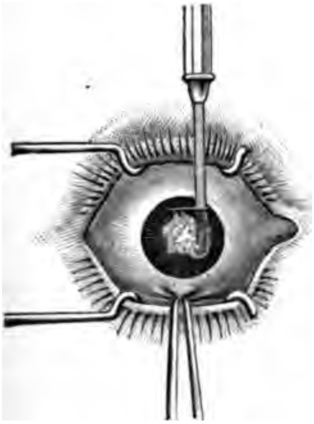

Fig. 96.—Streatfeild's Operation for Posterior Synechiæ.

In chronic iritis, the operation is practically the same as that for the formation of an artificial pupil, with the exception that it is more difficult on account of the dense adhesions of the iris to the lens capsule. Tyrrell's hook should be used to release these adhesions, but occasionally the forceps will be necessary. If the iris is bullose, it will be impossible to avoid tearing it. In such cases, after a portion of the iris has been removed, a Streatfeild spatula may be used to complete the loosening of the synechiæ. The iris may remain stationary even after released from the lens if atrophy of its fibres has occurred.

The re-establishment of the communication between the chamber of the vitreous and that of the aqueous may prevent a recurrence of iritis when all other treatment has failed.

Cyclitis.—Inflammation of the ciliary body usually occurs in combination with iritis or inflammation of the entire uveal tract. Occasionally it is observed as a separate and distinct affection. The term iridocyclitis is applied when, in addition to pronounced symptoms of iritis, there are neuralgia and tenderness in the ciliary region, most marked during efforts at accommodation, deposits upon Descemet's membrane, increased tension, and vitreous opacities. It is an extremely serious affection, and not only impairs vision, but may lead to destruction of the eyeball.

Primary cyclitis may be idiopathic in origin, but is most commonly due to ocular traumatism.

Owing to the close relation cyclitis bears to iritis, it may be divided into three principal varieties corresponding to those of iritis: plastic, serous, and purulent.

Plastic cyclitis may be acute or subacute, and is characterized by severe pain, marked ciliary tenderness, decided pericorneal injection, often of a purplish colour, deep anterior chamber, retraction of the base of the iris with dilatation of the pupil, and usually diminution in the intraocular tension.

The disease shows a marked tendency to extend to other portions of the uveal tract, and in such cases the condition is termed *plastic uveitis*. The resulting exudation permeates the anterior chamber, pupil, iris, ciliary body, vitreous, etc., and upon its subsequent contraction results in detachment of the retina, blindness, and atrophy of the globe. Degenerated and shrunken eyeballs following plastic iridocyclitis may remain quiescent for a comparatively long period, but a recurrence of the affection is always a possibility, and in such cases sympathetic ophthalmia in the other eye is always to be feared.

The cause of plastic cyclitis is usually injury to the ciliary body, such as occurs in penetrating wounds and cataract operations. Syphilis and tuberculosis are also ætiologic factors.

The treatment is the same as that recommended in plastic iritis. In the early stages the response to treatment is often prompt and the vision is retained in part, but in the greater number of cases the eyeball becomes useless as a visual organ.

Serous cyclitis is a chronic affection and is intimately associated with serous iritis. It is most common in young adults, and shows a marked tendency to recur. It is unilateral at first, but often attacks the remaining eye at a later period.

The affection arises from the same causes as serous iritis, particularly syphilis, gout, rheumatism, and tuberculosis.

Its manifestations are largely those of serous iritis with the addition of punctate deposits upon Descemet's membrane, deepening of the anterior chamber, turbidity of the aqueous, dilatation of the pupil, vitreous opacities, increased tension, and marked impairment of vision, all of which vary widely in their intensity.

Conditions such as chorioiditis, scleritis, and glaucoma are likely to supervene in the course of serous cyclitis, and complicate it considerably.

The treatment is also similar to that of serous iritis, but it must be remembered that in some cases, particularly those in which the tension is greatly increased, eserine or pilocarpine must be substituted for atropine.

Purulent cyclitis always consists of a purulent iridocyclitis. It may be non-infective, in which cases there is hypopyon in addition to the symptoms of acute iritis and cyclitis combined. The septic variety is most frequent and follows infective ulcer of the cornea, and septic wounds following traumatism and operations. It may also be induced by septic emboli in the course of pyæmia, septicæmia, meningitis, and cerebro-spinal meningitis.

In the severe cases there is present marked pericorneal injection, swelling of the lids, congestion, and chemosis of the conjunctiva, pus in the aqueous and vitreous, increased tension, and severe ciliary neuralgia.

The treatment is that of purulent iritis. Panophthalmitis, blindness, and shrinking of the globe are common terminations.

TUMOURS OF THE CILIARY BODY

The most frequent morbid growth of the ciliary body is sarcoma, and this tumour may occur in two forms: the small round-cell and the myxosarcoma. It makes its appearance first as a brownish mass posterior to the iris and induces glaucomatous symptoms. As it enlarges it produces symptoms common to other ocular sarcomata. Gummata, primary and metastatic carcinomata, adenomata, and myomata of the ciliary body have been reported.

The treatment consists in enucleating the eyeball as soon as the growth is discovered in all these tumours with the exception of the gumma, in which prompt antisyphilitic treatment causes its rapid absorption.

INJURIES OF THE CILIARY BODY

Injury to the ciliary body is always a serious condition, owing to the frequency with which plastic iridocyclitis is thereby produced and the possibility of sympathetic ophthalmia in such cases. An area of 5 millimetres in width surrounding the cornea represents the location of the ciliary body, and is termed the " danger zone," as wounds in this region are almost certain to implicate the ciliary body. The direction from which a foreign body or penknife enters the " danger zone " should always be most carefully noted. The sclera alone may be wounded, and the ciliary body escape; in such cases the wound is not serious. Care should always be taken to note this distinction on account of the difference in the prognosis.

Treatment.—In the absence of prolapse of the ciliary body or iris or of a foreign body thorough cleansing, together with the instillation of atropine and the application of cold compresses, will suffice unless complications occur.

Prolapse of the iris or ciliary body requires abscission of the prolapsed portion, and the solid stick (silver nitrate) applied to the wound to insure rapid healing. Wounds of the sclerotic that are not infected may be sutured if no foreign body is present.

The prognosis should always be guarded. Sympathetic ophthalmia is likely to occur in most cases, but occasionally the eye is restored almost to its normal condition.

CHAPTER IX

DISEASES OF THE CHORIOID

The situation of the chorioid between the retina and sclera, and its continuation into the ciliary processes and iris, often cause it to be diseased as a result of morbid processes in those structures. It is made up largely of blood-vessels and pigment-cells supported by delicate connective tissue, and it is these elements that are altered by pathological affections of the chorioid. Its function is that of nutrition, and any inflammatory or other condition interfering with its performance results disastrously to the retina, vitreous, or lens.

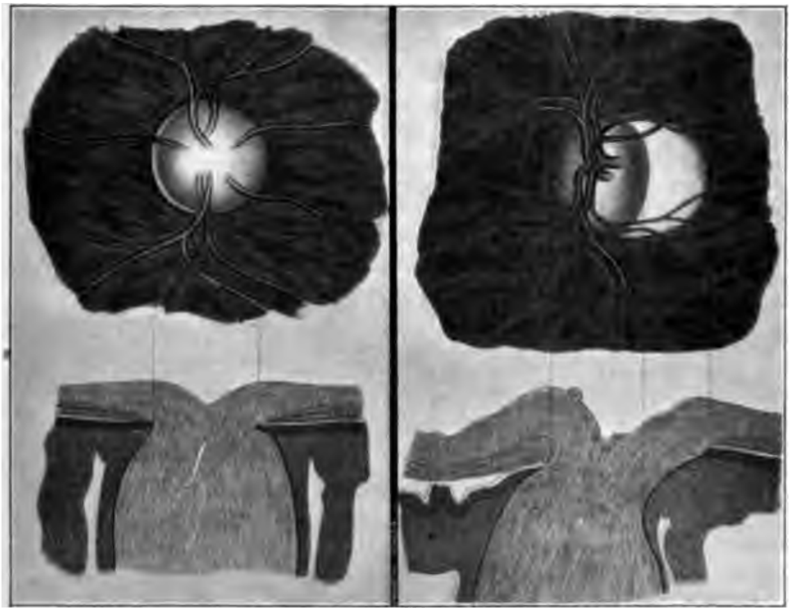

Fig. 97.—Normal Fundus. Large Semilunar Conus.

Diseases of the chorioid seldom give rise to external manifestations, but are detected by the ophthalmoscopic appearances they present. After the subsidence of the diseased condition and its exudate has been absorbed, traces of the disease remain in the shape of highly pigmented patches with a general diminution in the colour of the fundus and white atrophic areas.

It is important to distinguish these appearances from the variations in the chorioid in perfect health. The pigment may be large or small in amount, normally depending upon the complexion of the individual, and when in excess is most marked in the macular region. In the dark races the fundus has a uniformly slate-coloured appearance, while in fair persons and young children the vessels are darker in colour than the pigment interspaces. In dark persons the colour of the interspaces is deeper than that of the vessels, and they appear as islands of pigment. In old age there is a physiological decrease in the pigment epithelium. The blood-vessels of the chorioid are distinguished from those of the retina by the absence of the light streak along their centres. Hæmorrhage in the chorioid may be differentiated at times by the rounded outline and the superimposed retinal striation, but usually the exact location of fundus hæmorrhages escapes detection.

CONGENITAL ANOMALIES

Albinism.—Albinism is characterized by an absence of pigment from the uveal tract, and is accompanied by yellowish-white hair, eyebrows, and eyelashes, and the absence of pigment from the skin. The iris is generally of a pink or lavender colour, and the pupil may show a red reflex even by ordinary illumination. In the most pronounced cases strong light is unendurable to the patient. The defect is probably hereditary, and in many cases is attended with very marked errors of refraction, especially astigmatism and hyperopia; nystagmus and strabismus are common. The eyes are usually partly closed so as to lessen the amount of light entering them, and to diminish the effects of imperfect focusing.

Coloboma of the Chorioid.—Two forms of this congenital anomaly have been observed.[1]

In the more common form there is a deficiency of the chorioid extending backward from the ciliary region towards the optic disk; this form is frequently associated with coloboma of the iris. The other variety consists of a more or less circular defect of the chorioid, which may be located at the macula or in other parts of the fundus.

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[1] See Chorioidal Fissures in chapter on Development of the Eye—page 30.

In the first form the gap is frequently crossed by retinal vessels, and occasionally by chorioidal vessels. The margins of the coloboma are generally pigmented, being of a brownish hue. This condition is distinguished from chorioidal atrophy and opaque nerve-fibres, chiefly by its symmetrical pyramidal form, and by the pigmentation of its margin.

HYPERÆMIA OF THE CHORIOID

A condition of congestion of the chorioid precedes all inflammatory affections of that structure, and also accompanies eye-strain, exposure to heat and light, and the instillation of cocaine, homatropine, adrenalin, etc. This condition is extremely difficult to detect, and is seldom recognised. It is often confused with exposure of the chorioidal vessels subsequent to absorption of the pigment epithelium.

Symptoms.—There are no subjective manifestations. Viewed through an ophthalmoscope the fundus presents a "woolly" appearance and lacks the normal uniform red colour. The nerve-head is distinctly red and is surrounded by striations of the retina.

Treatment.—The examination of the refraction should be performed under mydriasis in these cases, and usually relief will be brought about by the constant wearing of the correcting lenses. When the hyperæmia passes over into true inflammation more active measures should be employed.

CHORIOIDITIS

A condition characterized primarily by hyperæmia and later by exudation and hæmorrhages into the chorioid. As the exudate is absorbed the diseased areas are replaced by connective tissue and appear as white atrophic spots. It may be associated with diseases of the sclera, iris, or retina, or it may exist independently. In most cases subjective symptoms are absent. A diminution in the visual acuity commonly results proportionate to the destruction of the eye-ground. The diagnosis is made by means of the ophthalmoscope, and depends upon the alterations in colour of the fundus, due to changes in the pigment epithelium and blood-vessels, hæmorrhage, and exudate.

Causes.—Probably the most frequent cause of chorioiditis is syphilis, inherited or acquired, although a certain proportion of cases occur in individuals of the strumous diathesis. Knies states that "chorioidal affections of an asthenic type are much more frequent in hereditary syphilis than in other conditions." It is also attributed to eye-strain and nutritional disorders. The more acute forms in which the formation of pus is a prominent manifestation arise from direct infection by the entrance of foreign bodies or through perforating wounds, septic operations, perforating ulcer of the cornea, all forms of pyæmia, and the infectious fevers.

Treatment.—Although each individual case requires special treatment according to its extent, duration, and character, all necessitate certain routine procedures. The frequency of syphilis as a cause demands the prompt administration of mercury and the iodides to combat any of its morbid processes. The eye should be afforded absolute rest and protected from exposure to bright light by wearing bandages or dark glasses. Free purgation and blood-letting are also of value. The correction of any ametropia serves to lessen the congestion of the chorioid. Suppurative chorioiditis requires antiseptic lotions and other measures adapted for lessening purulent inflammation, but as this variety is but a part of a panophthalmitis, enucleation is usually necessary.

Prognosis.—In the suppurative forms of the disease, blindness is almost an invariable result; and the eyeball is shrunken to a marked degree. In the non-suppurative varieties, while the prognosis is not so grave, there is a diminution of vision proportionate to the extent and location of the morbid process. Chorioiditis in the macular region lessens visual acuity to a greater extent than does a more diffuse inflammation at the periphery.

For convenience in description, chorioiditis may be considered as acute and chronic. The acute variety is usually suppurative in character, although an acute form of serous chorioiditis is sometimes observed. Its causes are for the most part local. The chronic form is never attended by pus formation, and is subdivided into serous, plastic, sclero-chorioiditis, and retino-chorioiditis.

SUPPURATIVE CHORIOIDITIS—METASTATIC CHORIOIDITIS

Suppurative inflammation of the chorioid is characterized by the presence of a purulent exudate between the retina and the chorioid, which usually extends, infecting the vitreous and often the entire uveal tract.

Causes.—It may be secondary to iritis or irido-cyclitis, but in most cases follows the introduction of septic material into the eye either through penetrating wounds or by means of the blood-stream.

Under perforating wounds may be mentioned the infection following the entrance of foreign bodies, sloughing and perforating corneal ulcers, unclean operations upon the eye, particularly cataract extraction, etc.

The infection carried by the blood-stream is that associated with pyæmia and the infectious fevers. Puerperal sepsis, endocarditis, septicæmia, cerebro-spinal meningitis, measles, dysentery, septic thrombosis and embolism, cholera, typhoid fever, gonorrhœa, etc., may be factors in the production of this condition. The cases thus caused are usually classified as metastatic chorioiditis. In one case of purulent chorioiditis under the observation of the author the infection was traced to gonorrhœa, and at the time of the appearance of the ocular condition gonorrhœal rheumatism in both knee-joints was well marked. The patient died of general pyæmia.

Symptoms.—The appearance presented by an eye the subject of this affection is that of a general inflammation of all the ocular structures. Early in the course of the disease it is possible to view the fundus and to locate areas of suppuration by their yellowish reflection, but soon the vitreous and lens become cloudy, so that a yellow reflex fills the entire pupillary area. Pain is present from the beginning, and the absorption of the septic material induces headache, malaise, loss of appetite, constipation, and elevation of temperature with an increase of the pulse-rate. Congestion of the anterior segment soon appears and the iris becomes discoloured and sluggish in action. The pupil is widely dilated and the anterior chamber is shallow. The cornea is hazy and lustreless, and there is considerable pericorneal injection. Chemosis of the bulbar conjunctiva and conjunctivitis with a muco-purulent discharge are present. The eyeball becomes very hard during the height of the inflammation, but shrinks and becomes soft with its subsidence, constituting phthisis bulbi. The eyelids are greatly swollen and inflamed. The extension of the inflammation is rapid and soon involves all the ocular structures, giving rise to the condition of panophthalmitis.

Treatment.—If the disease is the result of a local irritation, foreign body, dislocated lens, etc., the cause should be removed as soon as possible. If due to systemic metastasis, one may only hope to control the pain and try to lessen the suppuration. While enucleation is not advised as long as the cellular tissue is involved, my experience has been that enucleation should be performed as soon as the eyeball shows evidence of general inflammation of the inner tissues and light perception is lost.

The patient should be kept in a dark room. Mercurial inunctions, as well as large doses of calomel, may help to lessen the severity of the inflammation. Leeches and hot fomentations aid in relieving the pain.

Prognosis.—The outlook is always unfavourable. Vision is invariably lost. Connective tissue forms between the various structures, causing them to be bound down in every direction. This undergoes contraction, inducing shrinking of the entire globe. When enucleation has not been performed and a shrunken eyeball results there is danger of a recurrence of the inflammation or sympathetic ophthalmia. Ossification of the chorioid may also occur as a sequel.

Bone Development in the Chorioid.—This condition is not infrequently met with in eyes which have undergone atrophy and become shrunken. The bone formation is generally found in the inner layers of the chorioid. True osseous growths occur in the eye only as a consequence of plastic inflammation of the capillary layer of the chorioid. These osseous deposits may appear in the form of small spots or plates, the process of ossification being identical with the formation of bone in periosteum. The pain produced by this condition may be slight, or it may be very severe, often giving rise to sympathetic inflammation. The author has invariably found bony growths in atrophied eyes of ten years' duration.

The eyeball should be enucleated.

Chronic suppurative chorioiditis has been described by Fick and others, and very rarely occurs. It has no external manifestations and is detected by the yellowish colouration in the fundus when examined by means of the ophthalmoscope. It is often associated with pseudo-glioma (see Vitreous Diseases), and may be confused with true glioma of the retina.

NON-SUPPURATIVE CHORIOIDITIS—CHRONIC CHORIOIDITIS

Serous Chorioiditis.—Of this type of chorioiditis two principal forms are distinguished—namely, one constituting acute inflammatory glaucoma, and the other, which is more simple throughout its course, involving the adjacent tissues to a far less extent. (The former will be considered under the subject of Glaucoma.) The latter form presents no marked objective symptoms, except, perhaps, very slight irritation, slight injection of the eyeball, and a diffuse cloudiness of the vitreous humor, in which a few delicate floating opacities may be seen. The intraocular tension is increased, and the condition may be mistaken for glaucoma, to which it may lead in time. Quite frequently the iris becomes discoloured, the pupil somewhat dilated and perhaps slightly adherent, the aqueous is secreted in larger quantity and becomes turbid, having small delicate particles of lymph suspended in it. After the subsidence of the simple serous chorioiditis or chorioido-iritis, examination with the ophthalmoscope shows that the humours have again become clear, and that no permanent changes have been produced in the chorioid.

Plastic Chorioiditis.—*Varieties.*—Chorioiditis disseminata simplex; chorioiditis areolaris; chorio-retinitis centralis or circumscripta, and chorio-retinitis disseminata syphilitica.

This form of chorioiditis is usually binocular, and in its incipiency is hardly distinguishable by the ophthalmoscope from the normal fundus, with which the student is, of course, familiar.

The characteristic condition of plastic inflammation of the chorioid can, however, only be studied with the ophthalmoscope. Hyperæmia accompanies the acute stage of this disease, and the patient may complain of "flashes of light," even though he is in a darkened room. The retina, lying in contact with the affected chorioid, may become involved, thus leading to impairment of vision, and a sensation as of a cloud before the eye (positive scotoma). The lens and vitreous may also become opaque and further impair the vision.

When the disease has advanced to the later stages it presents the most striking and characteristic ophthalmoscopic appearances, which cannot fail to arrest the attention of even a superficial observer. This, however, is not the case in the earlier stages of the disease, especially at its commencement, since the small, round, grayish-white spots of exudation are very easily overlooked, even by the more careful and experienced observer. These round spots vary greatly in size, some being extremely small, while others are of considerable size. Later in the course of the disease these exudations are absorbed, and atrophic changes of the chorioid ensue, the sclerotic becoming visible in places as white patches surrounded by girdles of black pigment. These girdles are caused by the absorption of pigment epithelial cells around the atrophic patches.

The disease extends from the periphery of the fundus towards the posterior pole of the eye, so that eventually the whole background becomes mottled with innumerable atrophic patches, of varying size and shape, surrounded by pigmented girdles, and, perhaps, separated from each other by healthy chorioidal tissue.

The variety termed chorioiditis areolaris is confined to the posterior pole of the eye, chiefly in the neighbourhood of the yellow spot. The spots are large, oval, or circular in shape, of a white or yellowish-white hue, and chorioidal vessels are faintly visible in their area. Although they are chiefly grouped around the yellow spot, they are separated from it by healthy chorioidal tissue. These spots are encircled by broad zones of pigment, brownish or blackish in colour.

Quite often it is noticed, when the posterior pole of the eye is thus affected, that a few spots of exudation are also scattered here and there at the periphery of the eye.

We cannot, with a certainty, diagnose the syphilitic form of chorioiditis, though some authorities consider that certain lesions are more particularly characteristic of this type of chorioiditis than of the other forms. It probably shows itself most frequently in the form of numerous small, white, circumscribed patches, punched out, surrounded by a faint reddish zone, which exhibit little or no tendency to extend or coalesce, even when they are grouped closely together. The vitreous is peculiarly opaque, on account of very fine, dust-like particles floating in it.

Plastic chorioiditis is also known as central chorioiditis when the changes are most marked in the macular region. This is most common in elderly people, and seems to affect both eyes to the same extent. It is considered by some authorities to be one of the manifestations of senile decay of the vascular system. Vision is markedly diminished and central scotomata are present. The chorioid is atrophied and there is a deposition of pigment around the macula lutea. Its occurrence in young people is attributed to syphilis or some other constitutional disturbance.

Diffuse chorioiditis is also a subdivision or clinical type of this affection. It begins with cloudiness of the retina and vitreous with circumscribed exudation in the macular region. Later, the affected areas assume a dirty gray colour and irregular outline, being eventually replaced by atrophic and pigmented patches. The cloudiness of the vitreous disappears and the vision, particularly colour perception, is notably diminished. This variety is considered as syphilitic in origin.

Sclerotico-Chorioiditis, Anterior Staphyloma, Anterior Sclero-Chorioiditis.—This is the result of an inflammatory process in the chorioid and adjacent sclerotic, whereby the latter, becoming weakened, gives way under the normal or increased intraocular pressure. The staphyloma may be at any point, but it is generally at a short distance from the corneal margin, about the entrance of the anterior ciliary arteries. If the staphyloma is at all extensive, very serious consequences are almost certain to follow.

Sclerectasia Posterior, Posterior Sclero-Chorioiditis, Posterior Staphyloma.—The process which leads to the formation of a posterior staphyloma differs from that which results in an anterior staphyloma. In the latter case an inflammatory process is generally responsible for the condition, while in the former case it is usually conspicuous by its absence.

Anterior staphyloma is most frequently due to increased intraocular pressure, and is usually found in children under fifteen years of age. Posterior staphyloma, on the other hand, is more common between the ages of fifteen and twenty-two years.

A large posterior staphyloma may continue, or may induce chorioidal inflammation, or glaucomatous symptoms, and for these reasons the patient is always in constant danger.

Posterior sclero-chorioiditis is usually present in high degrees in myopia, and invariably in progressive myopia, and must be regarded as a grave complication of this condition. The affected eyes usually appear larger than normal, are prominent, and ovoid in shape. The antero-posterior diameter of the eyeball is increased, and the infundibulum or hollow, which is seen in the normal eye between the outer canthus and the globe, has disappeared. If the disease is extensive, the lateral movements of the eye are slightly curtailed, and the patient complains of a sense of fulness and tension of the eyeball, as if it were too large for its socket. The connection of glaucomatous symptoms with the stationary (non-inflammatory) type of posterior staphyloma shows that the recession of the posterior pole of the eye acts as a preventive of glaucoma—a fact which, perhaps, is not often enough remembered.

Chorio-Retinitis.—Involvement of the retina is always present in extensive cases of chorioiditis, particularly those due to syphilis. The symptoms are largely visual disturbances.

Treatment.—Before instituting treatment, it is, of course, desirable to determine the cause of the chorioiditis. If there is a clear history of syphilis, or even if this is only suspected, the method of treatment to be adopted will be evident. In the simpler forms of chorioiditis the treatment consists chiefly in the instillation of atropine, and the application of blisters or leeches behind the ear. The affected eye should be given perfect rest, and guarded against exposure to cold, and to bright light. Diaphoretics, as well as diuretics, often prove useful, and in all cases a "mixed treatment" will not be amiss, since this tends to hasten the absorption of the inflammatory products—the vitreous opacities. Should the patient be anæmic, it is well to correct this condition by tonics.

Examination of the visual acuity will disclose variations in the estimation of the size and shape of objects from time to time, and this is corrected to a great extent by the administration of mercury, iodides, and belladonna. The refraction is always unusual in character and also undergoes marked changes in very short periods, often necessitating frequent changing of glasses. The correcting lenses should be worn constantly to relieve the chorioid of any additional congestion, such as follows eye-strain. In the more severe forms of chorioiditis the use of atropine is not advisable, except where iritis coexists, on account of its tendency to produce increase of tension, which condition must, if possible, be avoided. Whenever there is marked increase of the intraocular tension, an iridectomy, or at least a paracentesis of the anterior chamber, should be promptly performed. If indicated, the latter operation may be repeated at intervals of three to four days.

In exceptional cases chronic chorioiditis is attended by severe pain, relief from which is afforded only by the administration of morphine, chloral hydrate, paraldehyde, or some other anodyne. Such cases are attended by progressive failing of vision, and occasionally resists all forms of treatment requiring enucleation for relief of the pain.

Prognosis.—The prognosis in diseases of the chorioid must be guarded, and is, on the whole, unfavourable. In the serous type of this disease there is a greater chance of arresting the progress; in the other types, the best that can be hoped for is to afford relief to the patient while the disease is progressing. The plastic is not so serious as the suppurative type. Chorio-retinitis is grave as regards vision.

NEW GROWTHS OF CHORIOID

Carcinoma of the Chorioid.—According to De Schweinitz, 27 cases of chorioidal carcinoma have been reported. Of these, 7 were bilateral and the remaining 20 unilateral. It will thus be seen that carcinoma of the chorioid is very rare. It occurs either as a medullated or as a melanotic carcinoma. Carcinoma of the chorioid is generally secondary to tumour of the breast. These tumours are not very easily diagnosed, and in order to ascertain their true nature it is necessary that a microscopical examination be made. In the diagnosis it should always be remembered that a carcinomatous growth develops more rapidly than a sarcomatous growth, leads at an earlier period to metastatic affections, and manifests a great tendency to involve the lymphatic glands.

On microscopic examination the medullary carcinoma is seen to consist of numerous areolar spaces, formed by the connective tissue, and within these spaces are contained the nests of cancer-cells, the latter being variously shaped.

The melanotic variety is only distinguished from the medullary variety by the more or less considerable pigment contained in the cells and the trabeculæ forming the areolæ. This type of cancer is extremely dangerous, and after excision is very prone to recur at an early date.

At times this tumour is of a mixed variety, being a combination of sarcoma and carcinoma.

The treatment for these tumours is the same for both sarcoma and carcinoma—namely, the exenteration of the eye as soon as the diagnosis is established with a reasonable degree of certainty.

In the Finsen treatment of cancer the actinic rays of the arc-light are now being utilized with success, and it is possible that this form of treatment may be applicable in the variety under discussion. The application of the X-ray is also advisable.

Sarcoma of the chorioid is the most common tumor of that structure, and may be composed of round or spindle cells. It may be pigmented (melano-sarcoma) or non-pigmented (leuco-sarcoma), the former being more common. It is essentially a malignant growth, being slow in onset, but later rapidly destroys all tissue in its neighbourhood with the formation of a fungoid mass and similar metastatic growths in the viscera. Although it is usually encountered in middle-aged persons, it may develop at any time of life. Men seem to be affected with greater frequency than women, and the left eye is most often attacked. The growth is always primary, single, and involves but one eye. It develops from the connective tissue of the chorioidal vessels and remains encapsulated by the chorioid for a comparatively long period. In the early stages the tumour is circumscribed and spheroidal in

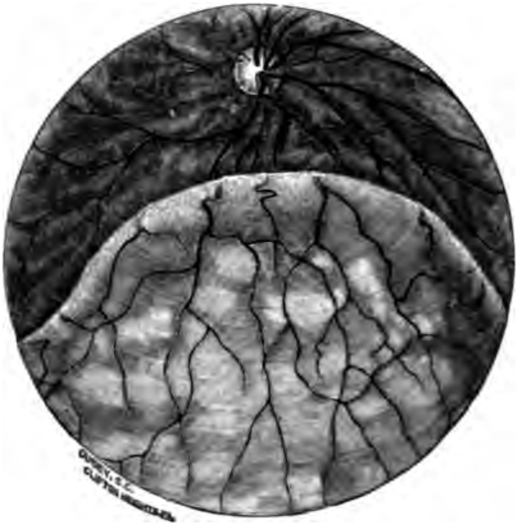

FIG. 98.—SARCOMA OF CHORIOID. (Author's case.)

form and is seen as a small nodular mass situated near the posterior pole of the eye to the outer side of the papilla. Occasionally it springs from the anterior or lateral portion of the chorioid. Of greater rarity is the diffuse sarcomatous infiltration of the chorioid reported by some observers.

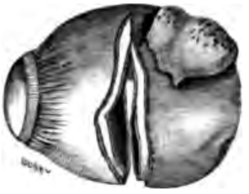
FIG. 99.—SARCOMA OF CHORIOID. (Gross specimen.)

In the very early stage it is impossible to state with certainty the exact condition present within the eye. Usually there are no symptoms to attract the attention towards that organ. The situation of the tumour may induce visual disturbances. Examination of the fundus at this period will reveal a condition not unlike that of detachment of the retina, but distinguished from it by the situation of the chorioidal vessels immediately beneath the retina.

With the increase in size of the growth irritative or inflammatory symptoms arise of a glaucomatous character. Increased tension is present, together with pain in the eye and head, shallow, anterior chamber, anæsthesia of the cornea, etc. Examination of the fundus becomes impossible on account of the cloudy condition of the media and the growth. Irido-cyclitis and sympathetic irritation of the other eye may be induced.

A further increase in the size of the growth causes it to perforate the sclera, after which the tension falls and the pain is lessened. The growth progresses rapidly in this stage with the protrusion of a fungoid mass that involves all adjacent structures. Although it usually perforates anteriorly, it may do so posteriorly, when it results in marked exophthalmos. The optic nerve and brain may be attacked.

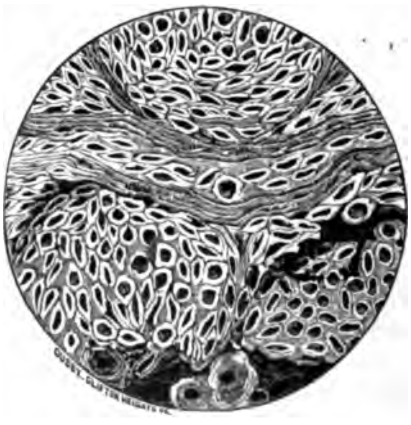
FIG. 100.—SARCOMA OF CHORIOID. (Microscopic section.)

The last stage is characterized by the formation of metastatic growths in the internal organs, especially the liver. A fatal termination is not long delayed after the appearance of these growths.

Diagnosis.—Sarcoma is a condition that is very rarely met with in childhood, and this should be borne in mind in the differential diagnosis from glioma of the retina—the latter occurring only before the age of ten or twelve years.

It is diagnosed from simple detachment of the retina by the reddish-yellow colour, the appearance of vessels beneath the retina, and the absence of the wavy motion of the detached retina floating on serous fluid; and from primary glaucoma, by the increased intra-ocular pressure, and the fact that it generally affects one eye only. After the tumour has pierced the sclera, its sections may be recognised under the microscope, or by its abundant pigmentation.

Treatment.—Complete removal of the eye is indicated. The spindle-cell variety may be permanently removed by this method, but the round-cell variety returns—often very promptly, though sometimes not for several years. The recurring growth generally is more rapid, and a second removal is necessary. The life of the patient is not materially prolonged by the removal of a round-cell sarcoma, but the pain may be abated and a respite secured. Cauterization or extensive destruction of tissue by Vienna paste probably retards the progress of the disease, but rarely cures.

If the growth cannot be entirely removed, treatment with mixed toxins of erysipelas and bacillus prodigiosus offers a slight chance of cure. The X-ray and Finsen-light treatment may also be tried.

Prognosis.—The outlook is always unfavourable. Death usually takes place within five years from the appearance of the growth when there has been no surgical interference. Recurrences have been reported as late as seven years after the removal of the affected eye. It is always impossible to determine the existence of small metastatic foci.

Tuberculosis of the Chorioid.—This is a very rare affection. Tubercles appear as small, round, yellowish spots, which grow quite rapidly without pigment changes, rarely reaching the size of the optic disk. They occur usually in the last stages of acute miliary tuberculosis.

The treatment is the same as for tuberculosis in other parts of the body.

Sometimes a single large tubercle resembling a sarcoma is observed, which produces the same destructive changes that a sarcoma would set up. If the patient's condition warrants it the eye should be enucleated, to prevent the spread of the tuberculosis to the other organs. This procedure, however, is of doubtful value.

Nodules.—In elderly individuals it is not uncommon for the lamina vitrea to become thickened and nodular near the equator of the globe. The structure consists of concentrically arranged lamellæ which are covered by pigment epithelium. They appear, ophthalmoscopically, as small round or egg-shaped patches emitting a wavy reflex. They are usually of no pathological significance, and affect vision only when near the posterior pole.

Among the very rare tumours of the chorioid may be mentioned cavernous angioma, adenoma, and enchondroma. They are difficult to distinguish clinically, and require microscopic examination of sections from these growths to make an accurate diagnosis.

INJURIES OF THE CHORIOID

Injuries of the chorioid may result from direct or indirect traumatism. Direct traumatism is exemplified by the formation of perforating wounds by the entrance of foreign bodies and of incised wounds by cutting instruments. Foreign bodies should be located by the X-ray or the magnet, and removed as soon as possible on account of the danger of suppurative chorioiditis and subsequent panophthalmitis. The eyeball, wound, and conjunctival *cul-de-sac* should be freely and frequently irrigated by antiseptic solutions.

Indirect traumatism consists in blows and similar injuries to the head and eyeball without the production of an open wound. As a result of such injuries, detachment, hæmorrhage, or rupture of the chorioid may result.

Detachment of the Chorioid.—This condition has only been reported a few times. In chorioidal detachment examination with the ophthalmoscope reveals a more or less globular protrusion in the vitreous of the eye. The surface of this small protrusion is free from wrinkles, being perfectly smooth, and here and there presents small retinal vessels passing over its free surface from the normal fundus. The colour of the mass varies from light yellow to dark red, depending upon the absence or presence of minute ecchymotic hæmorrhages. The detachment of the chorioid from the sclerotic may be caused by a neoplasm, or by an effusion of blood between these two layers of the eye.

The treatment has received very little attention, since such a small number of cases have been reported that the ophthalmologist has not been able to make a close study of the condition. Whether scleral puncture would prove of value is a question that remains to be determined by actual trial.

Chorioidal Hæmorrhage.—This is another very rare affection of the eye. The hæmorrhage may be either deep or superficial; it may be produced by a traumatism, such as a blow, or a wound involving the sclerotic and chorioid. It frequently occurs in diseases of the eye which disturb intraocular circulation—for example, glaucoma, posterior sclero-chorioiditis, etc. It may also arise from diseases, such as scurvy, purpura, etc. The blood may be effused between the chorioid and sclerotic, and, if the hæmorrhage is large, cause detachment; the extravasation may be confined to the tissue of the chorioid proper, or may take place between the chorioid and the retina. In the latter case, if the hæmorrhage is considerable, it may cause a retinal detachment, as explained in subsequent pages.

The differential diagnosis between retinal hæmorrhage and chorioidal hæmorrhage is made only with difficulty. Chorioidal hæmorrhages are generally more diffuse and have not the flame-like distribution characteristic of retinal hæmorrhages. When the hæmorrhage is in the neighbourhood of a retinal vessel, the latter may be seen to pass over the hæmorrhagic area, and thus afford aid in making the diagnosis.

Idiopathic chorioidal hæmorrhage should direct the physician's attention to the patient's general condition.

Rupture of the Chorioid.—Rupture of the chorioid is the direct result of a blow on the front of the eye. Owing to the hæmorrhage it is difficult to see the tear in the chorioid with the ophthalmoscope immediately after the injury, and it is only after absorption of the blood that a yellowish streak (usually curved) is noticed in the posterior part of the eye, somewhere in the neighbourhood of the macula. This band afterward changes from yellow to white and is usually outlined by pigment deposits. It may be possible to see two or more ruptures in the eye.

The retina itself may not be injured and the impairment of vision depends on the intensity of the lesion. The author has seen several cases in which the vision, at first seriously affected on account of the hæmorrhage, regains its normal condition after absorption of the hæmorrhage.

Prognosis may be said to be fairly good. If the rupture is broad and expanded, vision at that spot is lost and will not be regained; whereas, if the rupture is merely a rent in the chorioid, vision may be greatly interfered with, especially if the macula region is free.

Cicatricial tissue changes, if occurring in large numbers, have been known to cause detachment of the retina.

Treatment.—Leeches should be applied to the temple as soon as the condition is detected. Early in the affection the patient should be placed in bed, atropine should be instilled, and cold compresses should be applied. Formula 6 should also be employed locally. Internally, mercury with chalk should be administered in 2-grain doses three times daily. Later, gallic acid (10 grains) should be given every four hours. Saline cathartics and potassium iodide may also be employed to aid in the absorption of the extravasated blood.

CHAPTER X

DISEASES OF THE RETINA

GENERAL CONSIDERATIONS

THE diagnosis of diseases of the retina is best made with the ophthalmoscope, and it is here that this important instrument finds its chief usefulness and opportunity to display its excellence. But the use of the ophthalmoscope is a rigorous test of the physician's delicacy of perception and fineness of judgment, to which his experience must undoubtedly be added.

It should not be inferred by the student of ophthalmoscopy that ophthalmoscopic revelations of departures from the normal invariably point to the existence of general disease, however strong the probability, since it is still more certain that there are numerous exceptions which should not be forgotten. For instance, we are aware of the fact that nephritic or renal disease may exist for a considerable period of time before there are any characteristic indications observable in the retina. Further, we know that in only a few cases does the retina show any lesion; and, moreover, we also know that the retinal picture deemed pathognomonic not infrequently exists without any affection of the kidneys. Such limitations, however, must not lead us in any way to belittle the transcendent value and importance of ophthalmoscopic retinal study.

Most retinal affections or diseases are classified as forms of retinitis. In treating the different diseases of the retina both local and general measures are instituted; the latter, indeed, in many cases are of the greater importance.

The chief indication of retinal disease is impairment of vision. In other diseases there are abnormal after-images, or deficient power of recovery from the changes produced by exposure to light, which may lead to impairment of vision in strong light, or its undue impairment in diminished light: these last-mentioned conditions are known as day-blindness and night-blindness, respectively. Prolonged exposure of the eye to excessive light greatly impairs the sensitiveness of the retina; this is well shown in snow-blindness, a condition caused by the dazzling light reflected from snow on a bright winter day. An analogous condition is also produced by exposure to brilliant electric light.

Although a description of the healthy fundus and its anomalous appearances is given in detail under the discussion upon the *ophthalmoscope* (*q. v.*), a brief review of that subject at this time will aid greatly in obtaining a clear conception of the pathological changes in the retina.

The normal fundus varies widely in its pigmentation, and these variations, which are purely physiological, are often responsible for errors of judgment in the novice.

The retina itself is invisible, though in some healthy persons (rarely over thirty years old) there is occasionally seen a beautiful phenomenon, known as the "watered" or "shot-silk" appearance—a shimmer which flits over the surface of the retina, or centres about the macula like a half-invisible halo. This is a striking illustration of the interference phenomena of light, and is caused by the reflections of the ophthalmoscopic mirror from the anterior and posterior retinal layers that reach the eye of the observer in different phases, and, if they were sufficient in quantity, would produce iridescence, such as is seen in mother-of-pearl or butterfly's scales. This phenomenon is more common in dark-haired individuals, especially among Indian children.

With the exception of anomalies, the macula contains no vessels visible to the ophthalmoscope, and it often requires considerable time before the fovea and macula can be distinguished from the rest of the eye-ground. One may see the retinal vessels of his own eye by rapidly moving before his pupil a disk or stenopaic slit. The blood-vessels appear as if suspended in mid-air.

The arteries of the retina are relatively smaller than the veins, and show a light line running through their centres, which, if it exists at all in the veins, is much paler. No pulsation of the normal retinal arteries is observable, but venous pulsation is not infrequent. Arterial pulsation may be superinduced by glaucoma, and, perhaps, by pressure on the globe with the finger.

In health the papilla (optic nerve-head) appears as a nearly round disk, with definite boundaries, and has a clear, gelatinous, pinkish-white hue. The central depression, or cupping of the disk

—"physiological cup"—if present, may vary widely in degree without being abnormal, and in this physiological excavation the *lamina cribrosa*, resembling fine sieve wires, is plainly seen.

Opaque nerve-fibres is a congenital peculiarity sometimes met with, which, to the inexperienced eye, may closely resemble the appearance of the retina in albuminuric retinitis. At the lamina cribrosa the axis-cylinders of the optic nerve are usually divested of their medullary sheaths; sometimes, however, these are persistent, and, distributed upon the retina, produce white, comet-like patches radiating beyond the edge of the papilla. In slight cases they have no pathological significance, but increase somewhat the normal area of the blind spot, since the passage of light rays to the underlying retina is intercepted by the opaque sheaths; in extreme cases amblyopia is present.

Since the retina is normally invisible, it follows that deviations from the normal condition are indicated by its becoming visible; and, as a corollary, it follows that whenever it becomes visible for the physician, it has *ipso facto* lessened the visual powers of the patient.

FUNCTIONAL DISORDERS

Retinal Asthenopia.—One of the most frequent functional disorders of the retina is exhaustion of its nerve-elements. It is always secondary to anæsthesia, hyperæsthesia, or paræsthesia of that structure. Hysteria is a frequent cause, but excessive use of the eyes also often induces it. The condition is particularly frequent in dentists and others whose occupation subjects them to the glare of some highly polished surface. In dentists it shows itself as *gold-blindness* and is uninfluenced by age. The great stimulating effect of yellow upon the rods and cones is well known, and it is this excessive stimulation in these individuals that leads to exhaustion of the nerve-elements. The earliest manifestation of the affection is central scotoma without obvious cause.

Treatment.—Suspension of all near-work is indicated. Tobacco, alcohol, and similar substances should be interdicted. The refraction should be examined under a mydriatic and correcting glasses prescribed. Although under ordinary circumstances a tinted glass may be considered harmful, in these cases it affords astonishing relief, and it is my custom to prescribe arundel- or violet-coloured lenses.

Under this heading may also be described the various forms of blindness occurring as a result of exposure to intense light and due to excessive stimulation and consequent exhaustion of the retina.

Blindness due to Direct Sunlight.—This condition is especially likely to occur on the occasion of solar eclipses by attempts to observe the same with unprotected eyes. Immediately after exposure the following symptoms make their appearance: a dark or semi-dark spot in the centre of the field of vision; a peculiar oscillatory condition of the scotoma which tends to persist indefinitely; metamorphopsia, central colour scotomata, which may be of greater extent than the dark spot, etc.

The ophthalmoscopic examination reveals a translucent gray spot in the macular region surrounded by a ring of congestion. This is probably due to coagulation of the albumin of the retina, with vascular reaction, diapedesis of blood-corpuscles, and pigmentary disturbances.

Treatment.—Hypodermic injections of strychnine should be administered at regular intervals. Absolute rest of the eyes should be enjoined, and plane, dark glasses should be worn. The application of leeches or dry cups to the temple is often very efficacious. The constant electric current is also of value. The instillation of eserine is frequently productive of most gratifying results.

Prognosis.—The outlook is always unfavourable, as the scotoma may become permanent. Complete recovery is very exceptional, but in mild cases a decided improvement may be expected if the appropriate treatment is promptly instituted.

Blindness caused by Electric Light—Electric Light Ophthalmia.—This condition is dependent upon the intensity of the light. It has been observed, however, that the ordinary incandescent light has no permanent blinding effect on the eye. If the light is very strong, and the individual looks at the same for a long time, the same effect is produced as in the case of direct sunlight. The injurious effect of the electric arc-light on the eye has been variously attributed to the chemical action of the ultra-violet rays, to the accompanying heat-rays, and to dazzling of the retina. It has been shown that there is no coagulation of albumin of the retina. There is, however, an œdematous condition of the retina, with more or less destruction of the nerve-elements.

Treatment.—The treatment in this condition is similar to that of the preceding affection, but the subsequent results are more gratifying.

Snow-Blindness.—The exposure of the unprotected eyes for several days to the glare from an extensive surface of snow produces in some persons a peculiar form of ophthalmia, which may be followed by temporary or even permanent amblyopia. The face blisters and the skin peels off, just as in sunburn. The attack begins with the sensation of a foreign body in the eye, photophobia, blepharospasm, or excessive lacrymation; later on chemosis, with small opacities or ulcers of the cornea, makes its appearance. In some cases there is a form of secondary hyperæmia of the retina.

Treatment.—When there is risk of blindness, the eyes should not be exposed to the glare of snow or powerful electric light without being protected by smoked glasses. For the ophthalmia, cold applications and sulpho-carbolate-of-zinc lotions are recommended to relieve the distressing symptoms.

The inhabitants of the arctic regions, who are exposed to the blinding glare of the vast snow-fields, protect their eyes by a piece of pine wood which fits over the eyes, and has a narrow slit running horizontally before each eye, sufficient to give the individual a fair range of vision. The surface of the wood against the eyes is blackened, and the lids anointed with lampblack or charcoal and suet. It is very rarely that an Eskimo or Indian becomes snow-blind.

Prognosis.—The prognosis is quite favourable in the majority of cases; if, however, ulceration of the cornea takes place, the outlook is most serious.

Anæsthesia of the Retina.—A condition in which the sensitiveness of the retina is greatly diminished, characterized by a reduction in the acuity of vision and marked contraction of the visual field. There are no other symptoms, and the eye-ground is normal in every respect. It may be classified as follows:

a. The affection is not infrequent, and is usually observed in children from six to fourteen years of age of both sexes. It is most common in the children of the better class of people. The acuity of vision is rather suddenly diminished, and this diminution is manifested by the child becoming awkward and by stumbling over objects not in the direct line of vision. An inability to read except in a very strong light makes its appearance in a very short time, and soon the direct vision is reduced. At this stage of the affection the ophthalmologist is usually consulted, and a careful examination of the visual field will reveal marked contraction varying from 30 to 55 degrees and the reduction of vision to one-fifth normal. The colour fields are contracted proportionately and maintain their relation to each other. Scotomata are absent. The ophthalmoscopic examination reveals nothing abnormal. The pupils are semi-dilated and somewhat inactive. The patients are usually in good health and have no symptoms beside the great loss of vision. It is always of great importance to recognise this condition, as the appropriate treatment promptly brings about marvellous results.

Children between the ages of six and fourteen years are often subjected to neurasthenia, and this may be attended by ocular manifestations resembling anæsthesia. In a typical case of amblyopia of neurasthenic origin the patient complains of momentary headache, blurring of vision, disappearance of print when gazed upon for any length of time, inability to read without holding the book or paper very close to the eye, and similar disturbances pointing to fatigue of the power of accommodation. Upon examination these patients will be found emmetropic with normal amplitude of accommodation, but without marked contraction of the visual field. In addition there will be found manifestations of the neurotic disturbance elsewhere in the body, such as periodic alterations in the disposition, hallucinations of hearing, insomnia, vertigo, twitchings, areas of altered sensation upon the body surface, etc. In these cases rest with tonic treatment brings about a cure, but even then the course of the affection is prolonged. In anæsthesia of the retina there are no concomitant symptoms, and the response to treatment is immediate.

b. Nervous asthenopia is the term applied by Wilbrand, Fick, and others to a condition resembling in many particulars that just described as neurasthenic amblyopia. It is also attended by marked subjective symptoms, such as headache, lacrymation, blinding in a bright light, double vision, etc. It is hysterical in nature, and would seem to be due to hyperæsthesia of the retina. It is readily distinguished from retinal anæsthesia of the former class.

c. Hysterical amblyopia may be confused with retinal anæsthesia, but hysteria does not restrict itself to contraction of the visual field and reduction of vision, and while there may be an element of hysteria in some of the cases of latter affection, it is not fair to assume that the condition is always a form of hysteria in the absence of other manifestations of this disorder.

In the number of cases (17) of retinal anæsthesia under my observation, which followed the course in the description (*a*), I am naturally led to consider it as a separate and distinct condition from those just differentiated from it. The novice may be misled into believing this class of cases to be secondary to some error of refraction, but recourse to the perimeter will correct this mistake in diagnosis.

Treatment.—The application of the constant electric current is curative in class *a*. A weak current should be employed, and the applications should be made daily. The negative pole should be placed over the eyeball and the positive pole over the opposite temple or nape of the neck. A period of ten minutes is sufficient for each sitting. The fields should be taken daily during the treatment, and marked improvement will be observed within a few days. Recovery is prompt after this treatment has been instituted. The same treatment with tonics is applicable to classes *b* and *c*.

Hyperæsthesia of Retina.—A condition in which the sensitiveness of the retina is greatly increased. Prior to the discovery of the ophthalmoscope this condition was usually mistaken for inflammation of the retina, and even at the present day it is yet erroneously described in some text-books on ophthalmology. Such an error in diagnosis is important, as it is followed by improper and injudicious treatment, and leads to an aggravation of the symptoms with an increase in the duration of the retinal hyperæsthesia.

The affection is usually observed in young adults, and particularly in females of a neurotic or hysterical temperament. It is also associated with uterine disorders and menstrual disturbances. It may occur as a manifestation of hysteria, or it may be brought about by accidents, shock, blows upon the head or eyeball, prolonged use of the eyes in a very bright light, or even moderate exposure to an intensely dazzling light. Oxaluria is considered an important ætiologic factor by De Schweinitz. Headache, excessive venery, and naso-pharyngeal irritation are also said to be causes.

There is always present photophobia, lacrymation, and blepharospasm of varying degrees. The photophobia is often extremely intense, and may be suddenly induced by close application to near work.

The pain, a ciliary neuralgia, is very severe, and extends to the corresponding side of the face and head. The irritability of the retina is manifested by photopsia, and bright dazzling stars, coloured rings, etc., are seen to float before the eyes. The retina retains images for an abnormally long period, so that the image of an object is perceived after the object has been removed from the visual field. The fundus is perfectly healthy and the refracting media remain perfectly transparent. Vision is very slightly, if at all impaired, and is rendered comfortable by wearing coloured glasses. The intensity of the light is thus diminished, and reading at close range is aided considerably. The central vision is perfect, but the peripheral portion of the retina is anæsthetic, so that the field of vision, as has been pointed out by Von Graefe, is markedly concentrically contracted. At first glance the condition seems to resemble amblyopia from toxic or other causes, but a careful examination will serve to make a distinction.

Treatment.—Rest is essential in all cases. When the photophobia is intense it may be necessary to confine the patient to a darkened room for a time, but usually the wearing of plane coloured glasses will suffice to relieve this annoying symptom. Reading and other near-work should be interdicted. Tonics and outdoor exercises aid also in restoring the ocular condition to normal. Turkish baths, massage, and static electricity are valuable adjuncts. The following formula as a local eye lotion is very helpful:

℞ Acid. boric. Sod. chlor.	āā gr. xx;
Aq. destil.	℥i;
Aq. camph.	℥iij.

M.

Sig.: Bathe eyes freely three times daily.

For internal medication nothing has given the author such good results as the following pill:

℞ Strychnin. sulphatis	gr. ss;
Extract. aconiti, Acid. arseniosi,	āā gr. i;
Extract. belladonnæ	gr. ij;
Phosphor. resinæ, 4-per-cent (Pile)	gr. xij;
Zinc. valerianatis	gr. xxx.

M. Div. in pill No. 21.

Sig.: One pill three times daily.

Paræsthesia of the Retina.—A condition in which the sensations of the retina are altered or perverted. Such a condition gives rise to photopsia, inversion of the colour-fields, hallucinations of sight, and similar visual disturbances. It never occurs alone, but is always combined with other affections, particularly retinal hyperæsthesia. As its underlying causes may be mentioned hysteria, neurasthenia, oxaluria, etc. The treatment is that of retinal hyperæsthesia.

ORGANIC AFFECTIONS OF THE RETINA

Anæmia of the Retina.—Anæmia of the retina may be local or constitutional in origin. The former is most frequent and may be acute or chronic. *Acute anæmia* of local origin arises from occlusion, compression, or spasm of the retinal arteries. It is particularly well marked in embolism of the central retinal artery. *Chronic anæmia* of local origin usually follows some retinal disease in which atrophy of the vascular structures is a prominent feature. The constitutional disturbances that are accompanied by retinal anæmia are general anæmia, chlorosis, cholera, erysipelas, whooping-cough, migraine, typhoid fever, and poisoning by drugs, such as lead, quinine, bromides, and the salicylates.

The condition is manifested by blindness, temporary or permanent, according to the cause, with extreme narrowing and contraction of the arteries and pallor of the optic disk. Retinal changes occur in all chronic anæmias and are manifested principally as hæmorrhages and retinal plaques. They are very frequent and are disproportionate to the anæmia. In malignant gastric tumours they are found almost constantly. These retinal changes are purely functional and devoid of any significance.

The direction from which the blindness approaches is of value in making the diagnosis according to some observers. Priestly Smith, for instance, states that retinal anæmia is accompanied by blindness that approaches from above downward in contradistinction to the lateral blindness characteristic of cerebral involvement.

Treatment.—General anæmic individuals should receive the usual course of tonic treatment at all times. The occurrence of temporary blindness in the course of migraine or the infectious fevers may be relieved by the inhalations of amyl nitrite or the administration of nitroglycerine. Strychnine, digitalis, strophanthus, and similar drugs may also be employed.

Hyperæmia of the Retina.—An increase in the blood supply of the retina never occurs as an idiopathic affection, and is recognised by the increased redness of the optic disk with striations at its margins and dilatation of the larger blood-vessels. Owing to the variation in the width of the retinal vessels in health, it is extremely difficult to recognise departures from normal. Marked dilatation and tortuosity of the retinal vessels indicates hyperæmia in most cases. Arterial hyperæmia always precedes retinitis, but is seldom if ever detected. Venous hyperæmia is most marked in heart disease and thrombosis of the central retinal vein.

Among the causes of retinal hyperæmia may be mentioned general plethoric conditions, such as pneumonia and sthenic fevers, mitral disease of the heart, local ocular inflammations, eye-strain, emphysema, exposure to excessive light and heat, and thrombosis of the retinal vein.

The diagnosis of the condition is difficult, and in most cases must be inferred by the changes in the disk, although these are common to many affections.

Treatment.—As patients with retinal hyperæmia complain of no symptoms referable to the retinal condition they seldom consult an ophthalmologist unless there are other ocular disturbances. The most frequent of these accompanying conditions is ametropia, and in such cases atropine should be instilled and the refraction carefully examined. Local or general depletion will be necessary in hyperæmia due to plethoric conditions.

Retinal Œdema.—Serous effusion into the retina is present in all inflammatory conditions, particularly in albuminuric retinitis. It also follows contusion of the eyeball, in which condition it is characterized by transitory clouding of the retina. The acuity of vision is diminished to a corresponding degree, but this diminution is only temporary. Restoration to normal occurs within a few days in these cases.

Retinal Hæmorrhages.—Hæmorrhages may occur in connection with retinal inflammation constituting *hæmorrhagic retinitis,* or they may take place independent of such affections, to which cases the term retinal apoplexy is applied. As a rule, these hæmorrhages are found near the large blood-vessels, but their size, shape, and position in the retina admit of wide variations.

Causes.—Hæmorrhages into the retina are most common in elderly people, particularly those with atheromatous changes in their blood-vessels, and often precede cerebral apoplexy. Heart disease, especially hypertrophy of the left ventricle, and kidney disease are ætiologic factors of great importance. Injuries, retinal embolism and thrombosis, sudden reduction in the intra-ocular tension, such as follows iridectomy for glaucoma, pernicious anæmia, disorders of menstruation, purpura, scurvy, pyæmia, and septicæmia, malaria, etc., are also to be included in the ætiology. Occasionally in youths of both sexes from fourteen to twenty years of age multiple retinal apoplexies may occur without obvious cause. These cases have also been attributed to obstinate constipation and suppressed menstruation. Retinal hæmorrhages are also encountered in fracture of the base of the skull, particularly when there is a sudden outpour of blood into the subarachnoid space. In unilateral subarachnoid hæmorrhage the retinal hæmorrhages are confined largely to the corresponding side.

Symptoms.—Vision is always diminished, depending upon the size and situation of the hæmorrhage. Hæmorrhages in the periphery may be attended by little or no visual disturbance, while a macular apoplexy will be followed by serious impairment of sight. Phosphenes and muscæ usually float before the eye, and in some cases everything seems unnaturally red.

When examined by means of the ophthalmoscope the hæmorrhages appear as cherry-red spots, varying in colour, according to their duration. If situated within the innermost layer of the retina the extravasation follows the direction of the nerve-fibres and has a striated or flame-shaped appearance. When located in the middle and outer layers of the retina the clot appears as a round or irregular blotch on account of the blood following the supporting layers of Müller's fibres. A subhyaloid hæmorrhage is present when the apoplexy occurs in the macular region between the retina and the vitreous.

Course.—At the outset of the hæmorrhage the clot appears bright red, but later becomes brownish red or brown. As the extravasated blood is absorbed the situation of the clot assumes a grayish or white apppearance, showing that the retina is destroyed in that portion. The presence of these areas is indicated by scotomata in the visual field, and the loss of vision is proportionate to their number and extent.

Treatment.—The measures usually advised are wholly inadequate to stay the progress of the affection. Rest, pressure bandage, absorbents, purgation, gallic acid, mercury and chalk, etc., may be employed with success in many cases. The underlying constitutional conditions should receive the various treatments recommended for them.

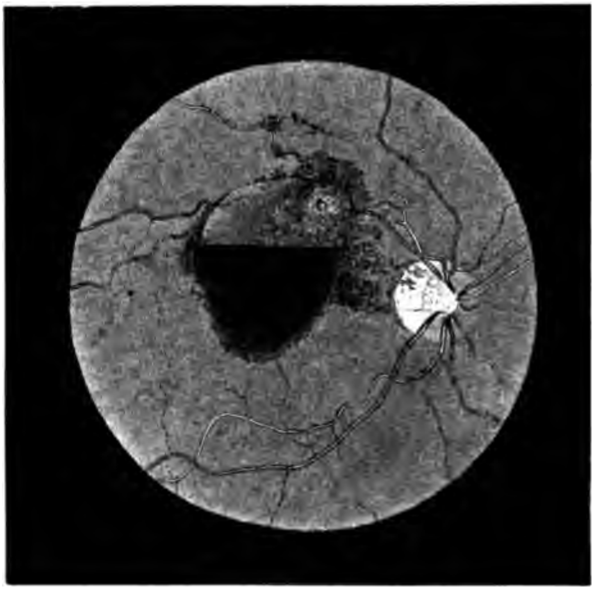

FIG. 101.—SUBHYALOID HÆMORRHAGE.

This represents the right eye of an elderly woman. The eye, in consonance with its myopia, shows a broad white crescent at the temporal border of its papilla; and the latter also has a pretty large physiological excavation. The retinal arteries are very tortuous, the veins normal. The middle of the fundus is occupied by a large hæmorrhage, covering the region of the macula lutea, and extending upward as far as the superior temporal vessels, which are partially concealed by it. The lower part of the hæmorrhage is dark red, and is separated by a sharp horizontal line from the upper, pale-red portion. This division into two parts is caused by the settling of the blood-corpuscles to the bottom of the still fluid blood. In the vicinity of the large hæmorrhage, especially at its upper and inner borders, lie numerous small spots of blood. These extend up to and upon the white crescent adjoining the optic nerve and up to the superior temporal vessels. From these vessels is derived the extravasated blood, which, after breaking through the limitans interna of the retina, gets between the latter and the vitreous, and sinks down to the region of the macula lutea, where even in the normal eye the connection between the retina and the vitreous is the least.

Prognosis.—Vision is always more or less altered. There may be but a few scotomata or complete blindness may be present. Retinal hæmorrhage is an unfavourable occurrence, particularly in elderly persons, in whom it usually indicates cerebral apoplexy some time in the future. It may also precede hæmorrhagic glaucoma, which always ends in blindness. In the young the prognosis is much more favourable.

VASCULAR CONDITIONS

Aneurysm of the Central Artery of the Retina.—This condition is characterized by great dilatation of the main branch of the central artery, or as miliary aneurysms, which may be considered as indicative of the presence of others in the small arterial branches in the brain. It is extremely rare as an independent affection, but miliary aneurysms may be occasionally observed in hæmorrhagic and albuminuric retinitis. No satisfactory treatment has as yet been devised owing to the infrequency of the affection.

Thrombosis of the Retinal Artery.—The formation of a clot or thrombus is also an uncommon affection. It may arise from a great variety of causes, among which may be mentioned failure of the heart's action with subsequent slowing of the arterial flow, disease of the vessel walls, and alterations in the quality of blood. The condition is most frequent in the aged and may follow phlebitis and various pyæmic conditions. It is preceded by transient attacks of blindness in the affected eye, and during the attack it is common for the vision to be greatly reduced if not absent in the unaffected eye. Headache, giddiness, and more or less faintness usually usher in the condition.

Ophthalmoscopic examination shows the fundus to be filled with hæmorrhages and a swollen, tortuous, and turgid condition of the veins. The retina is swollen to such an extent that the outlines of the optic disk are greatly obscured.

Treatment.—In all cases of transient blindness careful inquiry should be made into the condition of the blood and circulatory system. Often by the early detection of some vascular disorder and its prompt treatment it may be possible to prevent extensive thrombosis. During the attack manipulation of the globe and paracentesis of the anterior chamber have been advised. The treatment suggested under embolism of the central artery (*q. v.*) is also recommended here. After the subsidence of the acute stage the iodides, gallic acid, and mercury should be administered for their absorbent effect.

Thrombosis of the Central Retinal Vein.—This is also a very rare condition, and is met with chiefly in elderly persons with atheromatous blood-vessels and those who suffer from cardiac insufficiency. Inflammation of the cellular tissue of the orbital cavity from erysipelas or other causes may also produce thrombosis of the retinal vein.

Symptoms.—The retinal vessels are tortuous, the veins extremely thin, and the arteries greatly narrowed. The fundus is thickly studded with small dark red hæmorrhages which become absorbed and leave an atrophied retina with thready arteries. The optic papilla after a time becomes pale and atrophies.

Treatment.—The patient should be kept absolutely quiet, and put on a restricted diet, unless this is contra-indicated by his general condition. Saline laxatives may be given, or venesection resorted to, which measures give the desired relief in some cases. Subcutaneous injections of strychnine have been mentioned as aiding in the treatment.

Embolism of the Central Artery of the Retina.—Obstruction of the central retinal artery is manifested by rapid blindness, beginning at the periphery of the visual field and advancing towards the centre. The blindness may be total or partial according as the occlusion of the vessel is complete or incomplete.

Causes.—Valvular heart disease, especially acute endocarditis, arterio-capillary fibrosis, carotid or aortic aneurysm, pregnancy, Bright's disease, or chorea may induce the condition. Occasionally the embolus is pyæmic in character and leads to suppurative retinitis and subsequent panophthalmitis. In some cases the underlying cause escapes detection.

Ophthalmoscopic Appearances.—Examination of the fundus within a few hours after the occurrence of the obstruction will reveal a pale and œdematous condition of the entire eye-ground, most marked in the region of the disk and macula, becoming less pronounced as the periphery is reached. This cloudiness does not extend to the centre of the macula, and at a point corresponding to the fovea it is entirely absent. The fovea is replaced by a bright cherry-red spot characteristic of this condition. It is due to the red colour of the chorioid shining through the thinned retina in this situation. The arteries appear smaller than usual owing to the diminished blood supply and can be followed only for a short distance from the disk on account of the retinal œdema. The veins are also contracted, but not uniformly, and present alternate contractions and distentions resembling somewhat a string of beads. The contraction is most marked near the disk, the vessels becoming more distended as they approach the periphery. Retinal hæmorrhages may be seen especially in the macular region. Pressure upon the eyeball will give rise to the appearance of broken columns of blood with clear spaces between them. Occasionally it is possible to see such an intermittent blood-stream in the veins without pressure on the globe. The colour of the blood undergoes no characteristic alteration.

Course.—Vision is lost suddenly in all cases and may be complete or partial. If the main artery is obstructed even light perception will be lost, but if only a branch is occluded only that portion of the retina supplied by that branch will be paralyzed, while the function of the other portion will be temporarily diminished. Sometimes the visual acuity is very slightly affected in embolism of one of the branches. In the course of several weeks the œdema subsides and the retina regains its transparency. It becomes atrophic, however, although no visible necrosis takes place. At a still later period the optic nerve undergoes atrophic changes. The retinal vessels become less in number and are thin and filamentous in character. Occasionally an anastomosis exists between the retinal artery and some of the vessels of the anterior portion of the eyeball. In such cases a collateral circulation is established within a short time after the embolus has lodged and the nutrition of a portion of the retina is maintained, thus preventing entire loss of vision.

Treatment.—As soon as the condition is recognised efforts should be made to prevent any further changes in the eye-ground. Sometimes the embolus has become dislodged spontaneously and the circulation re-established. Gentle massage should be employed with this object in view, and inhalation of amyl nitrite should be prescribed to induce dilatation of the vessel walls. These measures should be employed three times daily for about ten days and absolute rest should be enjoined to prevent any increase in the arterial tension and subsequent retinal hæmorrhages. The internal administration of the iodides and mercury should be tried in an effort to hastily absorb the hæmorrhagic *débris*, etc.

Prognosis.—In thrombosis and embolus the outlook is very unfavourable, and if vision is not restored within the first two or three weeks the blindness usually persists.

INFLAMMATION OF THE RETINA

Retinitis is the general term applied to inflammations of the retina, and these are very seldom idiopathic in nature. It may occur as the result of extension of inflammation from neighbouring structures or it may be induced by constitutional diseases. It is always preceded by hyperæmia, and although each form has certain definite characteristics, all present certain features in common.

Visual disturbances are always present. Visual acuity may be greatly diminished and scotomata are frequent. Contraction of the visual field is also common. The light sense may be diminished, and micropsia, megalopsia, and metamorphopsia may be present. Pain is rarely a symptom, but the patient may complain of photophobia and ocular discomfort. The condition is usually bilateral.

Ophthalmoscopic Appearance. — The following are observed almost constantly:

Diffuse cloudiness, especially of the central portion of the fundus, due to loss of transparency in the retina, and consequent veiling of the chorioid.

Congestion of the optic papilla, the general outline of which becomes more or less indistinct, and gives rise to a general striated appearance of the retina around the optic nerve.

Vascular engorgement, the veins becoming greatly distended or engorged and tortuous. The calibre of the arteries is unusually diminished.

Hæmorrhages and whitish exudations follow the more severe cases, although the inflammation often subsides before this stage is reached.

Course.—The inflammation may subside with the return of useful vision, but more often the retina undergoes partial atrophy. A large number of cases undergo partial resolution and become stationary. This class of cases is often presented to the ophthalmologist on account of impairment of vision that cannot be improved by lenses. Examination of the fundus will show bright white patches, the edges of which may be pigmented, corresponding to areas of previous hæmorrhage. Upon taking the visual field these areas will be represented by scotomata. The blood-vessels of the eye-ground will be found contracted after severe inflammation and atrophy of the nerve may also be detected.

The various forms of retinitis are differentiated by the predominance of some of the signs already given, and also by the characteristic appearance and grouping of the exudations. Quite frequently the chorioid becomes involved, giving rise to the term retino-chorioiditis. Since retinitis is commonly the result of a constitutional disease, it may occur in both eyes, although not necessarily simultaneously, some time usually elapsing before the fellow eye shows evidence of the disease.

The most common cause of retinitis is albuminuria; probably next in order is syphilis. Brain diseases, diabetes, leucocythæmia, various forms of intoxication (lead, phosphorus, etc.), disorders of the blood, etc., also contribute their quota as ætiological factors in this disease.

SIMPLE RETINITIS

SYNONYMS: *Retinitis simplex; Œdema of the retina; Serous retinitis.*

In this form of retinitis there is usually a clouding of the retina, either in small areas or involving a large part of the retina in the posterior pole of the eye. The superficial layers alone are affected. There is marked hyperæmia, especially of the veins, which are dark and full, and often partly veiled by the haziness of the retina. Generally, only one eye is affected at a time, although both eyes may be affected simultaneously. There is impairment of vision over that portion of the field which corresponds to the portion of the retina involved. Hæmorrhages are very infrequent. Atrophy of the retina is the sequel.

Causes.—Simple retinitis may be the result of constant use of the eyes in fine work (eye-strain), disturbed nutritive processes, menstrual disorders, etc.

Diagnosis.—The diagnosis is made by excluding the causes of the special forms of retinitis. As a rule, the different forms of retinitis commence much in the same manner, and simulate simple retinitis, their special characteristics being acquired later in the course of the disease.

Treatment.—Rest of the eyes in moderate light; correction of errors of refraction; use of mild purgatives, followed by iodides and mercury in small doses. The general health of the patient must be looked after.

ALBUMINURIC RETINITIS

SYNONYMS: *Retinitis of Bright's disease; Renal vascular disease.*

Inflammation of the retina occurs in about 30 per cent of all cases of Bright's disease and presents certain characteristics that serve to distinguish it from other forms of retinitis, and that render it a diagnostic factor of no little importance in renal disease. Norris states that 25 per cent of cases of nephritis possess characteristic retinal changes; Eales shows its frequency to be 28 per cent; Galezowski, from his observations, concludes that it occurs in 33 per cent of all cases. In the early stages of Bright's disease the retinal changes are so slight that they nearly always pass unnoticed, but as the affection progresses the peculiar infiltration, œdema, exudation, and hæmorrhages make their appearance, and the condition becomes unmistakable.

The affection occurs with greatest frequency in those who are not incapacitated for their routine work by the kidney disease. One of the earliest symptoms is the loss of vision with headache, and for the relief of this symptom the ophthalmologist is consulted. Examination of the fundus reveals the characteristic retinitis, and the diagnosis can be readily confirmed by the results of a urinary examination. Very often these patients are unaware of any disturbance of their general condition until informed of it by the ophthalmologist. Although albuminuric retinitis may be seen in any form of kidney disease, it is encountered most frequently by the ophthalmic surgeon in connection with the cirrhotic kidney.

The age of the patient also exercises some influence upon the condition. The greatest number of cases is seen among middle-aged or elderly persons, but it is by no means rare to meet with it in the young. Bull has reported one case in a child five years old. The youngest patient with albuminuric retinitis observed by the author was eight years of age. In this case scarlet fever was the cause of the kidney disease, and there was double optic neuritis in addition to the retinal changes. The retinal condition in nephritis is usually bilateral in character, although unilateral cases are sometimes observed.

Albuminuric retinitis may be divided into two forms, acute and chronic. The acute form is more inflammatory in character than the chronic variety, and its predominating features are the swelling, congestion, and hæmorrhages of the retina. The chronic form is degenerative in nature and is characterized by numerous spots and hæmorrhages in the retina without any œdema or congestion. In actual practice it is impossible to distinguish these varieties from each other on account of their association in varying proportions in nearly all cases.

The relationship between kidney disease and retinitis is not well understood, but the cause of the ocular disturbance is probably an extension of the degenerative changes in the vascular system to the small vessels of the tunics of the eye. The severity of the eyeground symptoms seems to bear no fixed relation to the intensity of the renal disease, as the kidney affection may complete its course without any attenion being directed towards the eyes.

On the other hand, while the retinitis is not an early occurrence in nephritis it may be the first symptom recognised, and its importance in this connection is very great. It is of diagnostic importance in these cases, and usually indicates a fatal termination in from six months to two years unless prompt treatment is instituted. The infectious fevers that are liable to kidney complications are not infrequently followed by retinitis. The kidney changes of pregnancy also exercise an influence in its production. The retinitis that occurs during the kidney complications of pregnancy and the infectious fevers is more favourable and tends to clear up with the subsidence of the nephritis.

The possible ocular conditions that may arise in the course of nephritis are as follows:

1. Complete blindness unassociated with visible ocular changes; uræmic amaurosis.

2. Retinitis and neuroretinitis of a type peculiar to chronic nephritic disease.

3. Alterations in the calibre and relation of the retinal blood-vessels. Hæmorrhages and exudates may or may not be present or may occur without changes in the vessel walls.

4. The uvea may undergo marked alterations, manifesting themselves largely by changes in the iris and chorioid.

5. Lenticular opacities.

6. Impairment of function, and occasionally palsy of the extra-ocular muscles, particularly the superior oblique and the external rectus.

7. Recurring subconjunctival hæmorrhages. These usually

occur during the night and are discovered by the patient upon arising. Subcutaneous extravasation frequently accompany them. By many competent observers they are believed to indicate the actual existence of kidney disease, but in my opinion they occur as premonitory symptoms, being associated with generalized disease of the arterial walls,a condition that gives rise to the kidney affection. This conclusion was reached by the analysis of over 6,000 cases in the out-patient department of the Medico-Chirurgical Hospital during 1900, 1901, 1902, made for me by Dr. E. F. Kamerly, Jr., chief of the Medico-Chirurgical Ophthalmic Clinic. Of this entire number, 23 had recurring conjunctival hæmorrhages, but the most careful ophthalmoscopic and urinary examinations proved negative in all, excepting that the urine in each case showed an excess of oxalates.

Ophthalmoscopic Appearances.—In order to fully comprehend the possible changes in the fundus in this condition one must recall the statement previously made that it is essentially arteriosclerosis of the smaller and, when advanced, of the larger retinal vessels. This aids in explaining the occasional occurrence of albuminuric retinitis before the development of symptoms referable to the kidneys. The retinal condition is really an arteriosclerotic retinitis and the kidney disease is only another portion of the generalized arteriosclerosis.

Mr. R. Marcus Gunn's (London) classification of the ophthalmoscopic appearance in arteriosclerosis and consequent chronic renal disease is of great interest and importance in this connection.

1. The course and calibre of the retinal arteries are altered, as is shown by the undue tortuosity and the changes in the size and breadth of the arteries. There may be general contraction of one or more arteries or alternate contractions and widening, causing the affected vessel to assume a beaded appearance.

2. The translucency of and the reflection from the vessel walls also undergoes marked changes. The loss of translucency is manifested by an inability to view any underlying vessel. White stripes are found along the vessels due to degeneration of the walls or infiltration of the pericorneal lymph-sheaths. The entire breadth of the artery assumes an unusally light colour and the central light becomes more distinct than normal.

3. The course and calibre of the veins are altered considerably, and are associated with signs of mechanical pressure. These

changes are manifested by undue tortuosity, alternate contraction and dilatation, and an impeded venous circulation where crossed by a diseased artery. Ordinarily the crossing of a vein by an artery induces no pressure symptoms, and the translucency of the vessel allows a perfect view of the underlying vein. When the arterial walls are thickened by disease the vein is pressed upon or pushed to one side or its calibre is contracted, resulting in an ampulliform dilatation beyond the point of crossing. The venous walls are subject to the same changes as those of the arteries, resulting in white stripes and varicosities.

4. Retinal œdema occurs, as shown by a grayish opacity, near the disk or whitish spots scattered through the fundus following the lines of the vessels.

5. Hæmorrhages are frequent, and manifest themselves as linear extravasations along the course of the blood-vessels, rounded infiltrations, and subhyaloid hæmorrhages. Absorption of the hæmorrhage and subsequent atrophy is shown by the yellowish or whitish yellow spots bordered with pigment that are scattered throughout the fundus.[1]

Perhaps the earliest change in the retina is the fulness and dilation of the retinal veins, which are darker in colour and more tortuous than usual. The arteries remain normal or become slightly contracted. Hyperæmia of the optic disk occurs shortly afterward, and a faint, bluish gray, serous infiltration of the optic nerve and adjacent retina is soon noticed. As a result of this the margins of the disk are obscured and the chorioidal and sclerotic rings are completely effaced, so that the optic nerve seems to expand into the retina without any sharply defined line of demarcation. An extension of this exudation causes veiling of the retinal vessels, and the light reflex common to them is lost to a greater or less extent. Obscuration of the underlying chorioid is also produced in the neighbourhood of the disk. Retinal hyperæmia accompanies this infiltration, but is more wide-spread, as is evidenced by the small scattered hæmorrhages. As the condition advances the congestion becomes more marked, the veins are turgid and more tortuous, and the arteries are narrowed and partly hidden from view by the infiltration, at times being interrupted in their course by it.

The disk may become intensely swollen and its vessels completely hidden from view. In some cases the involvement of the papilla is so great that it becomes grayish red in colour, striated, and presents the appearance usually described as "woolly." Coincidently with these changes occur extravasations of blood into the retina of various sizes and shapes. They occur with greatest frequency in the internal layer of the retina, and the structure of this layer causes them to assume a flame shape. While striation of the hæmorrhages is most common, it does not exclude the occurrence of round or irregular extravasations. Occasionally, the number of retinal hæmorrhages is so great that the fundus appears of a dirty yellowish red tint. With the further progress of the retinitis areas of fatty degeneration occur which are particularly characteristic of this affection. They appear as large or small spots in any portion of the eye-ground, but are greater in number around the disk and in the macular region. As they increase in size they coalesce, and it is not infrequent to see the head of the optic nerve

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[1] See De Schweinitz, Proc. Phila. County Med. Soc., vol. xxiii, No. 8, 1902.

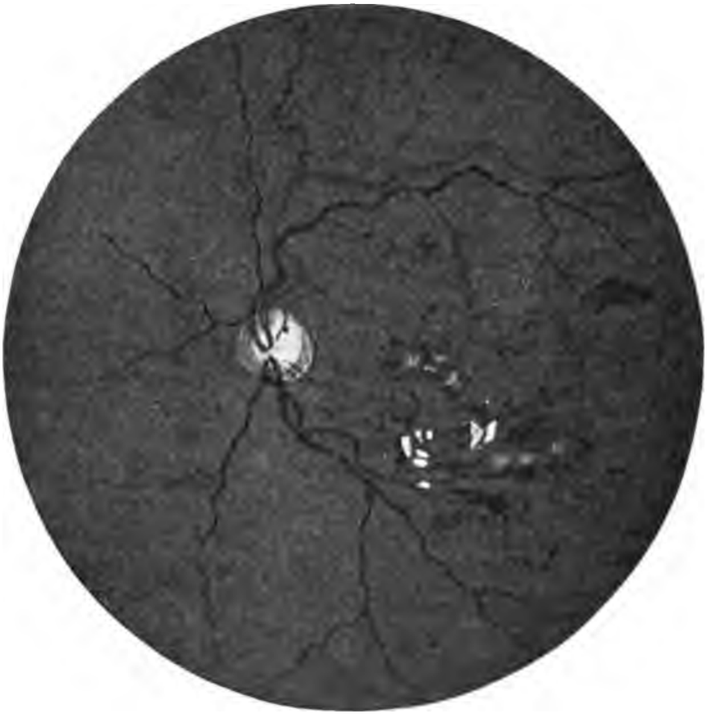

FIG. 102.—ALBUMINURIC RETINITIS. (Early stage.)

completely surrounded by a broad white wall, separated from it by a zone of gray or fawn-coloured infiltration. This broad white ring resembles snow to some extent, and has been designated as the "snow-bank" of albuminuric retinitis (Risley). It is especially characteristic of this affection. In the macular region appear numerous white spots, at first devoid of arrangement, but soon forming a star-shaped figure, made up of white glistening linear patches that radiate from the fovea, but do not involve it. This peculiar appearance was first described by Liebreich, and when seen it is pathognomonic. This discovery is also accredited to Mauthner. With the occurrence of greater exudation this "splashed" appearance is completely obscured and cannot be recognised.

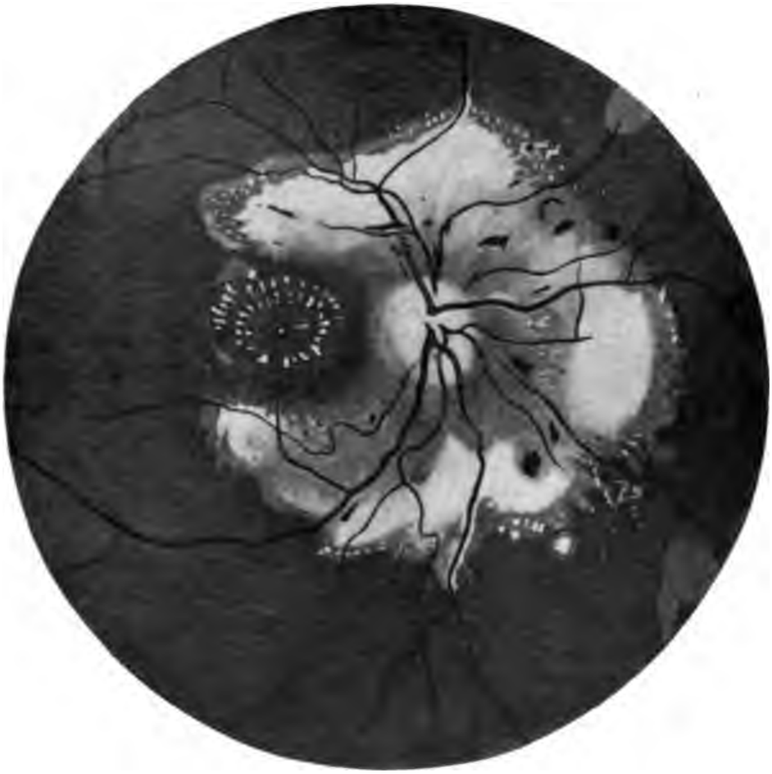

Fig. 103—Albuminuric Retinitis.

Pathology.—Congestion is the earliest change in the retina and causes dilatation and tortuosity of the blood-vessels. Serous infiltration next makes its appearance, and selects by preference the connective-tissue elements of the optic nerve and retina. In the optic nerve it gives rise to striation, which also arises from sclerosis of the fibrous tissue. In the retina it produces a veiled appearance and obscures the outlines of the disk and blood-vessels. The pathologic changes of the vessel walls and their undue engorgement leads to hæmorrhages through the retina, and the shape of these extravasations depends upon the character of the tissue in which they occur. Fatty degeneration of the cellular and connective-tissue elements, particularly of the granular layer, is responsible for the white patches scattered throughout the retina. The peculiar changes in the macular region are due to fatty degeneration of the radial connective-tissue fibres in this situation which normally converge towards the fovea centralis. Coincidently with the changes in the retina there are degeneration in the vascular system, nephritis, and hypertrophy of the left ventricle.

The blood also undergoes alterations, particularly when the retinal hæmorrhages and œdema are present. A marked hydræmia is almost constant.

Ewing, in speaking of chronic exudative (parenchymatous) nephritis, says: "The albuminuria and œdema of this group of cases are associated with well-marked anæmia, which, however, is subject to great variations on account of the intermittent course of the disease and of the frequent disturbing effects of treatment. The usual condition of the blood is one of moderate chlorotic anæmia. The majority of cases show between 3,000,000 and 5,000,000 red cells and 40 per cent to 80 per cent hæmoglobin."

The author has found this to agree with his observations in cases where œdema of the face coexisted with œdema and anæmia of the retina, and in which the blood-count was confirmed by Dr. L. Napoleon Boston, of the Medico-Chirurgical College.

In chronic interstitial nephritis J. C. DaCosta, Jr., writes as follows: "So long as circulatory disturbances do not exist, the condition of the blood remains practically normal, but as soon as the compensatory hypertrophy of the left ventricle becomes inadequate, the blood-changes identified with uncompensated valvular heart disease develop and various degrees of apparent anæmia and polycythæmia become evident from time to time." This, no doubt, accounts for the absence of retinitis albuminuria in this disease. We may have some colloid degeneration, but not the retinal hæmorrhages, since the blood nourishes the coats of the capillary blood-vessels of the retina, and thus prevents hæmorrhage. The change in the heart's action soon produces angiosclerosis in these capillaries, which are the most minute in the body, and also cause changes in the nourishment of the intergranular layers of the retina, which show later as white striæ or colonies of fatty degeneration, and hæmorrhages follow.

Diagnosis.—With the occurrences of changes in the eye-ground, such as already described, it is safe in most cases to assume the presence of albuminuric retinitis. Confirmation of this diagnosis, however, is always necessary, and this may be readily obtained by a careful history of all symptoms, an examination of the urine in detail, the presence of hypertrophy of the left ventricle, rigidity of the arteries, anæmia, uræmia, etc. The affection with which it may be confounded is neuroretinitis from other causes, but even then the condition is equally serious and the prognosis extremely grave.

Retinitis Albumosuria.—The condition known as albumosuria, described by Bence-Jones and others, is accompanied by retinal changes somewhat similar to those observed in albuminuric retinitis, so that one must be careful to make a distinction between these conditions on account of the difference in treatment and prognosis. Failure of vision is rather infrequent, but does occur. The patient more often complains of spots floating before the sight. In 4 cases, 3 whites and 1 negress, under my observation, the vessels of the fundus presented evidence of arteriosclerosis. In 3 of these cases the fundus reflex was yellow (pale saffron). Colloid dots were also seen above and below the optic nerve and white dots surrounded the macular region not unlike those of albuminuric retinitis. There were in addition hæmorrhages and whitish deposits scattered throughout the entire fundus. In one case choked disk was observed, and in another a diffuse retinitis was present. From this description it may be readily seen that the essential feature of this condition is arteriosclerosis of the retinal vessels; this is also common to the retinitis of kidney disease, so that in all cases presenting evidences of degenerative changes in the arterial walls the urine should be most carefully examined for albumin and albumose in order to eliminate either of these factors, that the condition may be assigned to the other. (For an interesting account of albumosuria, with a review of the literature, see paper by James M. Anders, M. D., and L. Napoleon Boston, M. D., Transactions of the College of Physicians, Philadelphia, 1902.)

Treatment.—The patient should be placed in charge of a skilled clinician as soon as possible, who should be informed of the patient's condition from an ophthalmic standpoint. In the absence of such aid the patient should be placed at rest and general treatment begun. The anæmia will indicate the use of iron, but its constipating effect will require considerable judgment to select the proper preparation. Basham's mixture is probably the best and is diuretic in action, in addition to being a tonic. Strychnine is of value on account of its effect upon the heart and blood-vessels. Gallic acid (gr. v to xv), three times daily, combined with gray powders (mercury and chalk, gr. i to ij), should be administered in all cases of retinal hæmorrhages, and especially in chronic Bright's disease. Free purgation and diaphoresis are of great advantage in eliminating the poisons retained through the disability of the kidneys. Alkaline waters may be consumed in large quantities for their diuretic action. The diet should be regulated so as to prevent excessive ingestion of albumin, and the patient should wear woollen clothing the whole year around. Removal to a mild dry climate is advisable. All work should be interdicted.

The occurrence of headache, vomiting, and transient blindness always points to the onset of uræmia and necessitates prompt measures.

Locally very little can be done. The instillation of eserine has beeen advised, but it serves only to lessen the irritability of the chorioid. Errors of refraction and failing accommodation should be treated in the usual manner as soon as compatible with existing conditions in order to diminish any tendency towards eye-strain. Rest of the eyes is of utmost importance, as any congestion induced by attention to close work is liable to increase the number of hæmorrhages.

Prognosis.—Vision is nearly always permanently impaired or lost, according to the number, extent, and situation of the hæmorrhages. The outlook as regards life depends upon the character and stage of the nephritic condition. When seen in the early stages of Bright's disease, and appropriate treatment is carefully carried out, it is possible to prolong life for many years. The kidney disorders of pregnancy and the infectious fevers respond very readily to treatment. As ordinarily seen, however, albuminuric retinitis indicates death within two years after the appearance of the ocular trouble. If the hæmorrhages in the retina are associated with fatty deposits (colloid) in a patient past thirty years of age death may be expected in from three to five months. Belts's statistics: In 155 cases in private practice 62 per cent died within one year, 85 per cent within two years, and 14 per cent lived more than two years. Out of the 175 hospital cases, 85 per cent succumbed within one year, 93 per cent within two years, and 6 per cent lived more than two years. In my own experience I can recall one case that lived seven years after the retinal condition, colloid degeneration, was recognised.

SYPHILITIC RETINITIS

This form of retinitis, which, according to Alexander, is found in 8 per cent of syphilitic cases, may be due to acquired or hereditary syphilis; in the former case it may make its appearance a year or more after the infection. The initial stages present the same objective symptoms as albuminuric retinitis: Hyperæmia, serous exudation, a gray or bluish gray, film-like veiling of the retina and papilla, increased tortuosity and dilatation of the veins, and proportional attenuation of the arteries. In the more advanced stages the white dots and spots about the periphery of the fundus are less brilliant and glistening than in the albuminuric type, and present greater variations. Opacity of the retina is most marked in a zone around the optic disk, or may be localized especially in the macula. Extravasations of blood, as a rule, are neither so frequent nor so pronounced as in albuminuric retinitis. Synchronous inflammation of the chorioid, iris, etc., which is certain to take place, renders the diagnosis more positive.

Among the subjective symptoms may be mentioned: Diminution of vision, which is observed in all cases, although in variable degrees; night-blindness or hemeralopia—i. e., excessive impairment of sight under weak illumination; and a persistent dazzling or shimmering of light that is very annoying. Metamorphopsia, and especially micropsia, attributed to the separation of the rods and cones by the effusion, are frequently observed.

Diagnosis.—When no other cause can be ascertained for a retinitis, the diagnosis of syphilitic retinitis should be made (Mauthner). This diagnosis will be confirmed by the finding of characteristic syphilitic lesions, or, negatively, by the absence of the other common cause of retinitis, in the majority of cases.

Treatment.—Mercury and the iodides, alone or combined, should be administered for a prolonged period together with the constant current. The attendant anæmia requires the employment of tonics, such as iron, quinine, strychnine, cod-liver oil, etc. The eyes should be placed at rest and the refraction should be examined at frequent intervals.

Prognosis.—The vigour of the treatment, and the stage at which it is begun, have, of course, an important bearing on the prognosis. Vision generally improves under proper treatment, especially if the causal disease can be controlled. It must be borne in mind, however, that vision is very rarely restored to normal, and in the majority of cases retinal lesions are revealed with the ophthalmoscope. It may be stated that the prognosis is rather more favourable than in albuminuric retinitis. Syphilitic retinitis exhibits a great tendency to recurrence, and some stubborn cases result in partial or total blindness.

DIABETIC RETINITIS

Various observers have from time to time noted the occurrence of retinal inflammation in the course of diabetes mellitus, but no characteristic features have been described in the eye-ground appearance that would warrant using the retinitis as a diagnostic symptom of diabetes. It is not a frequent condition, and resembles in many respects albuminuric retinitis. According to De Schweinitz the disease is always bilateral. The most common appearance of the fundus in this condition consists of small retinal hæmorrhages with fine glistening dots above the macula. According to Berry, the changes are less marked in the macular region. Hæmorrhages and opacities in the vitreous are common and high myopia and cataract are often observed. Sometimes the appearance presented by the retina in diabetes is not unlike that of albuminuric retinitis. It is seldom an early occurrence in diabetes, but usually presents itself near the termination of the affection.

The symptoms are those of ordinary retinitis with the addition of the various manifestations of diabetes.

Diagnosis.—A distinction between this form of retinitis and other retinal inflammations cannot be made with certainty by the results of an ophthalmoscopic examination alone, but requires careful and frequently repeated urinary examinations. The urine may contain both albumin and sugar, but which ever predominates and is found more constant by repeated examinations may be considered as indicating the cause of the retinitis.

Treatment.—The various dietetic and medicinal measures recommended for diabetes must be employed immediately, particularly if the diabetes has remained undetected until discovered by the ophthalmologist. Salicylate of strontium and salicylic acid administered internally are of great value. Rest of the eyes is indicated, but no local treatment will be of any use whatever.

Prognosis.—Sight is always greatly impaired even in the most favourable cases. Usually the prognosis is very bad, as the disease is near the completion of its course when the retinal condition is detected. The outlook becomes more favourable in proportion to the degree in which the diabetes can be controlled.

HÆMORRHAGIC RETINITIS

When hæmorrhages are spread over the retina and are so numerous as to overshadow the other findings, the term hæmorrhagic retinitis is properly employed. Hæmorrhages into the retina are common in many forms of retinitis, and may even occur without a coexisting inflammation of the retina. The condition, which sometimes develops rather suddenly, in the great majority of cases affects one eye only, or if both eyes are affected, one usually suffers more than the other.

Ophthalmoscopic examination will reveal numerous flame-shaped hæmorrhages scattered throughout the fundus, which is slightly swollen and opaque. If a case is carefully observed fresh hæmorrhages may be seen from time to time. White or yellowish spots or areas of pigment disturbance are usually present as the result of fatty degeneration, due to absorption of the blood. The papilla is red and swollen; the retinal veins are tortuous and dilated and often accompanied by white streaks; the arteries are more or less contracted. There may be extravasations into the vitreous. "Atrophic changes usually take place after some time, so that although the hæmorrhages may clear away, leaving often little or no trace of their existence, the vessels become narrowed and obliterated, the disk pale, and the field of vision concentrically limited, just as in atrophy of the optic nerve, until eventually the vision is completely lost" (Berry).

We occasionally find an effusion of blood on the surface of the retina, which, because it is not located in the retina proper, is termed subhyaloid hæmorrhage: such a hæmorrhage usually undergoes complete absorption with full restoration of visual acuity.

Causes.—This form of retinitis may occur idiopathically, or as a result of certain diseases of the heart and blood-vessels, among which may be mentioned aneurysm, endarteritis, atheromatous condition of the vessels in old age, hypertrophy of left ventricle, etc. Retinal hæmorrhages also occur rather frequently in newborn children (10 to 32 per cent), especially in difficult labours (Noyes). The author has had two cases of retinal hæmorrhage in infants six weeks of age. The mothers had discovered that the children were unable to see, and on making an ophthalmoscopic examination retinal hæmorrhages, especially about the macular region, were found. Purpura, scurvy, hæmophilia, and similar affections also induce it. Young anæmic females are frequent subjects. In some cases there is thrombosis of the central retinal vein. The recognition of a coexisting kidney disease would, of course, necessitate our classifying the retinitis under another head.

Hæmorrhages may occur into the retina in the absence of the causes already mentioned, and such cases can usually be traced to some abnormal condition of the blood. The results of repeated examinations of the blood in such cases under my observation have demonstrated a pathologic condition of each individual red blood-cell in every instance. The structure of the red cell being altered, its function is consequently impaired to a corresponding degree. As a result, the nutritional properties ascribed to the red blood-cells are deficient, and this deficiency affects mostly the *vaso vasorum* or nutrient vessels of the walls of the larger arteries and the walls of the capillaries. The absence of nutrient vessels in the capillary walls allows the walls of these structures to be involved themselves, and this is most manifest in the retina. The involvement of the *vaso vasorum* in the larger arteries seems to act as a safeguard, as the underlying condition is not permanent and a return to health can usually be produced before any serious changes occur in large vessels. With the impairment in nutrition of the capillary walls in the retina, marked weakening occurs and rupture and extravasation of blood are frequent. Examination of the blood at this time will show diminution in the amount of hæmoglobin, and reduction in the number of red blood-cells with changes in

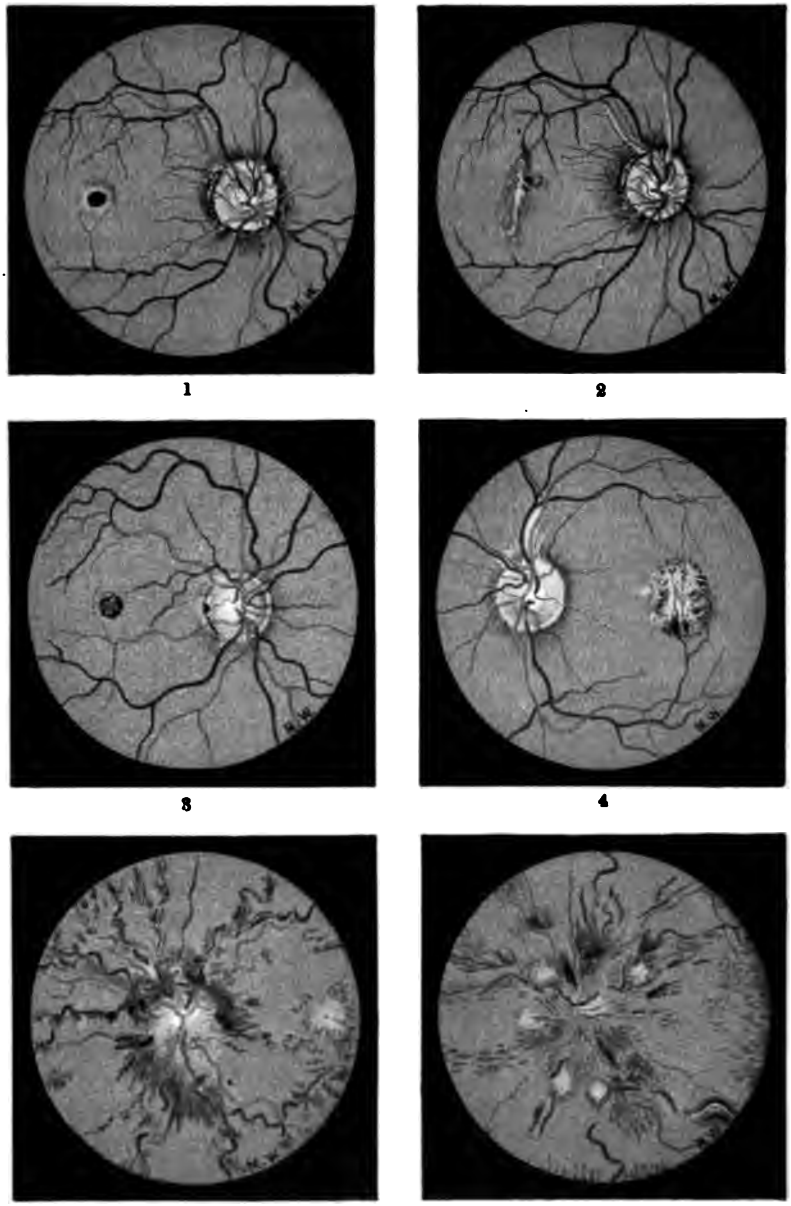

PLATE III.—RETINAL HÆMORRHAGES.

(Drawn by MARGARETTA WASHINGTON.)

1. **Macular hæmorrhage O. D.**
2. **Macular hæmorrhage O. D. four months later.**
3. **Cribriform depression of macula with hæmorrhage.**
4. **Connective tissue changes following macular hæmorrhage five years previous.**
5. **Retinal hæmorrhages following essential anæmia in a girl seventeen years of age.**
6. **Retinal hæmorrhages due to gouty diathesis in a woman sixty-six years of age.**

their size, shape, and structure. In 8 cases within the last year the blood examinations made by Dr. L. Napoleon Boston yielded the following results:

In 7 cases the hæmoglobin showed a marked diminution, varying from 51 to 76 per cent at the time of the first examination. The red blood-cells varied in number from 3,500,000 to 4,500,000 per cubic millimetre in all the cases in which the hæmoglobin was reduced. The reduction in the hæmoglobin was usually out of proportion to that in the red cells, so that taken singly each red blood-cell was especially poor in hæmoglobin. In one case the hæmoglobin was 95 per cent and the red cells numbered 5,690,000, showing the hæmoglobin equivalent of each individual cell to be about normal. In none of these cases was it possible to demonstrate any leucocytosis. In four of the examinations the leucocytes reached 10,000 per cubic millimetre, but this increase may be considered as physiologic, as the "count" was made during the process of digestion. At the time of the first blood examination, without exception, the central pale area, normally present in the red blood-cell, was noted to be enlarged, and occasionally extended almost to the periphery of the cell, indicating a reduction in the pigment or hæmoglobin in such cells. Many of the red cells displayed minute streaks and patches of pallor throughout their protoplasm, from which areas the hæmoglobin or colouring matter had been extracted, presumably by some degenerative process in the cells themselves. Achromacytes, red cells containing little or no hæmoglobin, were occasionally found, and pale macrocytes and over-coloured microcytes were common. With the institution of appropriate treatment, the blood and its various elements become normal in every particular, and simultaneously the ocular changes undergo involution.

In retinal hæmorrhages of this character the prognosis is not as hopeless as would first appear, since an examination of the blood will determine the diagnosis, and efficient treatment may be promptly begun.

Diagnosis.—This is not difficult, especially when the ophthalmoscope is used. The patient should, however, be closely questioned, in order to determine whether or not there is a history of diabetes, kidney disease, syphilis, etc.

Treatment.—Absolute rest of the eyes should be insisted upon. Local bleeding from behind the ear; cold applications to the eyes; careful attention to the patient's general condition—all these measures are of value. Subcutaneous injection of pilocarpine in small doses has been advised. The correction of abnormalities in the circulatory or digestive systems is of great importance—especially the former, since it may be a cause of the trouble. All manner of excitement is, of course, to be avoided. Tonics are especially indicated, but above all must be mentioned mercury and chalk in 1-grain doses and gallic acid in 5-grain doses, three times daily. The efficiency of the mercury-and-chalk preparation depends upon the property which mercury has in small doses of increasing the red blood-cells. The gallic acid, while belonging to the class of local astringents, is probably devoid of astringent properties after its absorption; empirically, however, it is of considerable value. After a prolonged treatment of this character the retina returns in large part to its original condition with a restoration of the blood to normal. The treatment must be continued for some time—six weeks to three months. Eserine locally also aids in keeping the tension of the eyeball reduced, and should be applied twice daily throughout the attack.

Prognosis.—This depends on the cause and severity of the hæmorrhage, as well as its position, and upon the patient's general health. The prognosis is bad if the macula lutea is involved. If there is extravasation of blood into the vitreous there is considerable danger of a subsequent rise of tension, which may cause a particularly intractable form of glaucoma—a frequent complication. There may be detachment of the retina, and scotomata, which will probably be permanent.

PURULENT RETINITIS

Purulent retinitis is a septic inflammation of the retina characterized by circumscribed whitish areas of fatty degeneration and suppuration in the macular region and near the papilla. It is usually bilateral in character, and occurs most frequently in the course of pyæmia, puerperal sepsis, and similar conditions. It is sometimes associated with purulent chorioiditis, but usually precedes this affection.

Causes.—The affection is always due to the presence of pyogenic micro-organisms in a retina already debilitated by injury or disease. These micro-organisms may gain access to the tunic through a penetrating wound produced by foreign body, or they may be carried to the retina in septic emboli by the blood-current. In the former instance acute purulent retinitis is brought about as an independent affection; but in the second, suppurative chorioiditis is induced at the same time, giving rise to embolic panophthalmitis. Panophthalmitis is the termination eventually in both classes of cases.

Diagnosis.—In the early stages it is extremely difficult to distinguish the affection with certainty. Ophthalmoscopic examination in every septic case would probably reveal the presence of whitish spots and hæmorrhages scattered throughout the fundus. Most cases, however, come under the care of the ophthalmologist after panophthalmitis has appeared and the diagnosis is made only by inference.

Treatment.—The underlying septic condition should receive the treatment usually prescribed for such conditions. Rest of the eye with the application of cold compresses is always indicated. Inunctions of mercury, leeching, and free purgation aid in checking the morbid process. Enucleation, however, is nearly always necessary.

Prognosis.—The eyeball as a visual organ is always destroyed. The outlook as regards life depends upon whether the general treatment is efficient in checking the causal septic condition. The best that can be hoped for is a useless eyeball that sooner or later requires enucleation.

LEUCÆMIC RETINITIS

Leucæmic retinitis is a very rare form of retinal inflammation, and is associated exclusively with splenic leucæmia. The affection is bilateral in character, but one eye is usually involved to a greater extent than the others. Failure of vision in the course of leucæmia is the first symptom that attracts the attention to the eyes. Examination of the fundus will reveal a diffuse retinitis with generalized swelling and opacity of the retina. The eyeground is pale yellow in colour. The optic disk seems somewhat swollen and its edges are obscured. There is more or less pallor of the surface of the papilla. Upon following the course of the blood-vessels the veins will appear broad, distended, and of a rose-red colour, while the arteries will become narrow and orange-yellow in colour. The chorioidal vessels when visible will present a yellowish red tint. In the region of the equator, and also near the macula, there are often seen more or less elevated whitish spots with hyperæmic borders. These areas result from an aggregation of lymph-corpuscles, while the more highly coloured border is due to an extravasation of red blood-cells. Hæmorrhages when they do occur are usually peripheral, but when in the neighbourhood of the macula may serve to confuse the condition with albuminuric retinitis.

Diagnosis.—The appearance of the fundus is usually characteristic, and the hæmorrhages may be distinguished from those of retinitis albuminuria by their more red colour and greater distribution in the periphery. Urinary examination may show albumin in the urine in both cases, but the other characteristic elements of nephritis will serve to make the diagnosis. An examination of the blood should be made in all doubtful cases. In leucæmia, the anæmia, and the enormous leucocytosis with the presence of eosinophiles and myelocytes will serve to make a distinction.

Treatment.—The treatment should be directed towards the underlying leucæmia, and tonics and stimulants should be freely prescribed. Local treatment is useless.

Prognosis.—The retinal condition shows no tendency to undergo involution, but persists as long as the disease of the blood lasts. It assumes a very chronic and somewhat stationary character, so that vision may be retained until death occurs. The leucæmia ends fatally in about two or three years in spite of the most skilful treatment. Blindness sometimes occurs before the end of the affection is reached. A case of this character, a patient of Prof. W. C. Hollopeter, was examined by the author at the Medico-Chirurgical Hospital.

ANÆMIC RETINITIS

Closely allied to the foregoing retinal condition is the retinitis seen in pernicious anæmia. It is manifested by a generalized œdema of the retina with numerous hæmorrhages. These extravasations of blood have white or gray centres. The entire eye-ground has a yellow appearance, and the head of the optic nerve is discerned as a dirty white spot. The veins are distended and the blood they contain resembles arterial blood.

Diagnosis.—The ophthalmoscopic appearances, while strongly suggestive of this condition, are not diagnostic, and an examination of the blood is necessary as a confirmatory test. The pernicious variety of anæmia is indicated by the decrease in number of the red blood-cells with various alterations in their size and shape and a reduction in hæmoglobin.

Treatment.—Here, as in most forms of retinitis, the treatment is entirely constitutional. Those measures intended to increase the constituents of the blood and restore tone to the body are indicated. Local treatment is of no avail.

Prognosis.—The retinal condition is not a very active process and tends to remain stationary for a long period, as in the preceding variety. Usually death occurs in from one to two years, but occasionally recovery takes place, so that treatment should be kept up until the end.

GOUTY RETINITIS

This variety of retinitis occurs in elderly individuals, who are also subject to other manifestations of gout.

There is impairment of vision, usually affecting both eyes, and indicated by yellowish white spots, or patches of exudation, in the region of the disk and macula. In some cases there are hæmorrhages of the retina, especially through the equator of the eyeball. In this form of retinitis there is marked contraction of the arteries and dilatation of the veins; the latter do not, however, present grotesque tortuosities, as in albuminuric retinitis. Moreover, the vessels throughout the body present evidences of marked angiosclerosis.

Examination of the urine reveals the presence of a large amount of uric-acid crystals; casts are absent and albumin rarely found.

Treatment.—From the very beginning our attention is to be directed to the gouty diathesis; the administration of antilithics and gallic acid is therefore indicated. The eyes should be bandaged in order to afford them absolute rest. The patient must avoid all manner of excitement. Failure of accommodation or errors of refraction should receive careful attention.

Prognosis.—Blindness does not usually occur in this form of retinitis, but if vision should once be lost, it cannot be restored. It is a well-known fact that fatal cerebral hæmorrhage terminates the majority of cases in this constitutional affection.

Uncommon Clinical Forms of Retinitis.—A number of cases of retinitis have been described by various authors that present distinct ophthalmoscopic differences, but which cannot be attributed to any one constitutional affection in each case. The principal of these forms are *retinitis circinata, retinitis striata, retinitis proliferans, retinitis punctata centralis,* and *angioid streaks* in the retina.

Retinitis circinata consists of a crescentic or annular arrangement of slightly elevated white patches about the macular region. Hæmorrhages into the retina may also take place. The characteristic of this condition is its peculiar localization.

Retinitis striata is characterized by yellowish white or gray streaks radiating from the head of the optic nerve to the periphery. Its origin is unknown.

Retinitis proliferans is distinguished from these other unusual types of the development of dense vascularized masses of connective tissue. These masses are whitish in colour and take their origin from the retina, subsequently projecting into the vitreous. They may be very extensive and obscure the disk and adjoining fundus. As complications of this condition may be mentioned newly formed blood-vessels, hæmorrhages, retinal detachment, and vitreous opacities. Syphilis is believed to be the underlying cause in most cases.

Retinitis punctata centralis is an affection of the retina in which numerous small white pin-point spots are scattered throughout the macula, but which do not involve the blood-vessels. A grayish appearance of the papilla may be observed and more or less central diminution of vision is noted. It frequently begins in early youth, though it may be seen at all ages. It is not uncommonly encountered in several members of the same family. Night-blindness and contraction of the visual field is an accompaniment.

Angioid streaks in the retina have also been described and consist of pigmented striæ throughout the fundus resembling a system of obliterated blood-vessels. Their true significance is unknown. Vision is seldom altered to a marked degree.

Symmetrical Infantile Macular Changes.—In that peculiar condition known as "amaurotic family idiocy" it is common to find changes in the macula that are characteristic of this condition alone. Both maculæ are involved, and the appearance of the fundus is similar to that seen in embolism of the central artery. Optic atrophy takes place, and is followed by gradual loss of sight. The affection begins in infants, and is attended by muscular weakness and general enfeeblement, terminating in death within one or two years. It occurs with great frequency in several children of the same family, and seems to select Jewish children by preference.

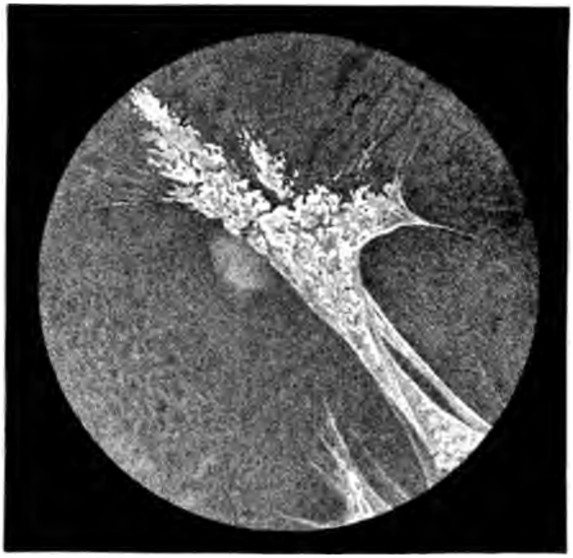

FIG. 104.—RETINITIS PROLIFERANS.

In a man, thirty-five years of age, who suffered frequently from palpitation of the heart and nosebleed, sudden obscuration of the sight occurred in both eyes five years ago. This obscuration has recurred repeatedly since, being due to recurrent hæmorrhages into the vitreous. In the vitreous of the left eye close to the papilla lies a shining white mass having a structure partly fibrous, partly granular. From this mass pass strands in different directions, some extending as far as the periphery of the fundus. No vessels are recognisable in the white mass, which covers the upper half of the papilla. The other half of the papilla and the rest of the fundus are somewhat hazy (owing to the presence of a faint opacity of the vitreous), and besides appear indistinct, because the ophthalmoscope is adjusted not for them, but for the connective-tissue mass, which is situated farther forward. Indistinctly visible are indications of the retinal vessels (above and to the outer side) and indications of a tessellation of the fundus (below and to the inner side).

Treatment is of no avail.

PIGMENTARY DEGENERATION

SYNONYMS: *Retinitis pigmentosa; Sclerosis of the retina.*

A degenerative condition characterized by an excess of pigment with atrophic changes in the retina. There is hyperplasia of the connective tissue of the vessel walls, causing them to become considerably thickened. The vessels of the chorioid also undergo a similar change by reason of a chronic endarteritis. There is no active inflammation present at any time, and the affection is believed to begin in the chorioid, the pathological changes in which cause migration of the pigment from the pigment epithelium into the retina.

Causes.—A great number of the cases are congenital in origin and make their appearance between the years of fifteen and twenty. The influence of heredity in producing this affection is undoubted, as it often occurs in several members of the same family, especially where there is a consanguinity of parentage. Patients with this condition are not uncommonly deaf and dumb or possess anomalies, such as supernumerary digits, hare-lip, cleft palate, etc. It is encountered with greatest frequency in the lower walks of life, and is not rarely accompanied by mental impairment or idiocy. It is always bilateral and may arise without any assignable cause.

Symptoms.—Vision is always impaired, and this is noticed at the age of puberty or shortly afterward. One of the most prominent symptoms is the inability to see in the dark or even in a feeble light. This gradually becomes worse until vision is so greatly reduced that the patient is able to see only when the object is placed directly in front of the eye. Coincidently with this is the contraction of the visual field, which becomes so marked that only a central portion of the field remains. The patient may be able to read at this stage, but there is a great inability to find his way alone. The condition is extremely chronic. The progressive diminution in vision and contraction of the visual field eventually end in complete blindness.

Ophthalmoscopic Appearance.—The fundus presents a peculiarly characteristic appearance in this condition that serves to distinguish it from syphilitic chorio-retinitis and similar affections. One of the most striking features is the presence of numerous stellate branching masses of black or brown pigment, resembling bone-corpuscles in shape, scattered throughout the periphery of the fundus along the blood-vessels. Sometimes the vessels seem to be encased in this pigment. As the condition advances pigment masses are formed within those already mentioned, gradually contracting the area of the fundus not involved. The loss of pigment from the pigment layer of the retina allows the chorioidal vessels to become plainly visible. The head of the optic nerve presents a yellow, waxy appearance, and gradually becomes atrophic. The retinal vessels become small and considerably contracted and atrophy of the retina takes place. At the posterior pole of the crystalline lens it is by no means infrequent to encounter a star-shaped opacity in addition to the retinal changes. Occasionally cases are observed in which the pigment is normal in amount and distribution, and in others the distribution only is atypical. Retinitis pigmentosa may be readily distinguished from syphilitic chorio-retinitis by the patches of chorioidal atrophy and the later appearance of the latter affection.

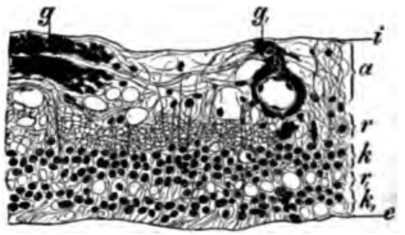

FIG. 105.—RETINITIS PIGMENTOSA. SECTION THROUGH THE RETINA. Magnified 170 × 1.

The retina is bounded on its anterior surface by the membrana limitans interna, *i*, upon its posterior surface by the membrana limitans externa, *e*; the layer of rods and cones that succeeds the latter has disappeared altogether as a result of atrophy. Succeeding the limitans interna is a coarse-meshed network, *a*, which has originated from the supporting tissue of the retina. The nerve-fibres and ganglion cells, which normally are inclosed in this supporting tissue, have been completely destroyed. The vessels, however, can still be seen, and are inclosed in pigment. One of them, *g* (very greatly contracted), has been divided longitudinally: another, g_1, transversely by the section. The succeeding layers of the retina—namely, the inner reticular layer, *r*, the inner granular layer, *k*, the outer reticular layer, r_1, and the outer granular layer, k_1—are altered, and here and there contain pigmented cells.

Treatment. — Although treatment is of very little avail, it should always be instituted. Internally, antisyphilic remedies should be tried, and tonics, such as strychnine, iron, etc., should be given in full doses. Errors of refraction should be corrected, and the eye should be protected from excessive light or sudden variations in the illumination by wearing violet-coloured glasses, in which the ametropic correction is incorporated constantly.

Cases have been reported in which the progressive contraction of the field was arrested by applications of the constant current and useful central vision maintained. During my term at Moorfield's Eye Hospital, London, 1881–'82, I had the opportunity to test the efficiency of this treatment in a number of such cases, and the improvement was marked, consisting in enlargement of the visual field and improvement in central vision. Its persistent use three times a week, extending over years, is therefore indicated.

Prognosis without treatment is serious, the majority of patients becoming hopelessly blind at from thirty to fifty. The spurious or syphilitic variety is more or less amenable to treatment, and the prognosis is consequently not as unfavourable.

ATROPHY OF THE RETINA

Atrophic changes in the retina may occur from a number of causes, and give rise to certain characteristic appearances. The head of the optic nerve becomes pale and of a yellowish or brownish colour. It assumes a hazy appearance, and its outlines are ill-defined. The retina loses its transparency and also becomes hazy. Marked pigmentation is usually present, but it may be absent. The walls of the blood-vessels become thickened as the result of an overgrowth of connective tissue, but later become narrow from the contraction of this new fibrous tissue.

All the layers of the retina are involved after conditions, such as retinitis, chorio-retinitis, pigmentary degeneration of the retina, and syphilis of the chorioid and retina, but the outer layers are attacked first.

After optic atrophy, optic neuritis, glaucoma, etc., the atrophic process affects only the layer of nerve-fibres and ganglion cells, leaving the outer layer intact.

In a typical case of essential atrophy of the retina in the advanced stage the appearance of the eye-ground differs in many particulars from other pathologic fundus conditions. The nerve-head is atrophic and rather well-defined, but instead of the white colour commonly associated with optic atrophy the disk may be said to have a putty colour. The retinal vessels are absent from the papilla, having been totally obliterated by the atrophic process. Here and there throughout the fundus a retinal vessel may be occasionally encountered as a thin red streak. The film-like structure of the retina that normally obscures the outlines of the chorioidal vessels is entirely absent except where it stretches across the chorioid as thin filamentous bands, inclosing small aggregations of the remnants of the retinal pigment. The absence of the retina exposes to view the vessels and pigment of the chorioid in their entirety, so that upon first gazing into the eye the observer is struck by the remarkable preservation of the chorioidal vessels. Their calibre is unaltered and the walls appear unchanged, the outlines being particularly well defined. The pigment of the chorioid is also prominent, but is uniformly distributed through the fundus located between the blood-vessels. In cases uncomplicated by chorioidal disease or hæmorrhages there are no white patches of scleral tissue present, nor are there any great aggregations of pigment. The affection is slow in onset and course and tends towards incurable blindness.

Gyrate atrophy of the retina is a clinical variety of this affection, described by Fuchs. It is very rare, and occurs nearly always in children. Consanguinity of parentage is ascribed as its cause. Night-blindness and contraction of the visual field are the only symptoms.

The ophthalmoscopic appearances are particularly characteristic. The disk is atrophied and its vessels narrowed. White atrophic dots form around it, increasing in number, and becoming gradually larger until they coalesce and form a broad white girdle, the edge of which is scalloped, completely surrounding the nerve-head, but separated from it by a zone of normally coloured fundus. The affection is closely related to retinitis pigmentosa.

DETACHMENT OF THE RETINA

SYNONYMS: *Coarctation of the retina; Amotio retinæ; Sublatio retinæ.*

This condition, as the name implies, is characterized by a separation of the retina from the chorioid. Normally, the retina is attached to the chorioid only at the optic nerve and ora serrata, being kept in place by the pressure of the vitreous. Detachment of the retina is therefore only possible when a force acting behind the retina is greater than the pressure of the vitreous; or when, as a result of disease of the vitreous, its pressure is diminished to such an extent that it becomes negative, or, in other words, exerts traction on the retina.

It has been shown by Leber and Nordenson that some cases of detachment are due to the traction of the shrinking vitreous, which tears the retina and permits some of the fluid contained in the space formerly occupied by the vitreous to find its way behind the retina and assist in the mechanism of detachment.

Effusions of blood or serum or tumours between the chorioid and retina frequently give rise to this condition. High myopia with posterior staphyloma and ocular traumatism are common causes. In some cases the condition arises idiopathically.

Retinal detachment occurs with greater frequency in men than in women, and attacks by preference individuals of advanced years. One eye alone is usually affected, but occasionally the detachment is observed in both eyes. In these cases the condition is of longer duration in one eye than in the other.

Symptoms.—There is loss of vision corresponding to the area of detachment, which is usually below the horizontal meridian of the eye, although it may have originated in some other portion. Objects in the upper portion of the field are therefore not seen.

Among the early symptoms may be mentioned flashes of light and apparent distortion of objects. The patient also complains of the appearance of a dark cloud before the eye. Involvement of the macular region renders the eye entirely blind.

Ophthalmoscopic Appearances.—The appearance of the fundus varies according to the character and extent of the detachment. Ordinarily, with the ophthalmoscope at a distance, the fundus reflex will be found not entirely red, but made up of a red and a bluish gray or white portion. The latter is irregular and made up of folds, and changes its position with the movements of the eye, so that at times the red reflex is completely obscured. In less marked cases it is necessary to bring the instrument closer to the eye to detect the condition. The detached portion will appear as an opaque gray membrane which may wave freely in the surrounding fluid. In flat detachments, such as are caused by a growth behind the retina, the membrane is but slightly altered, and the condition can be detected only by the elevation at this point. The amount of the elevation may be determined by comparing the refraction of a blood-vessel on the summit of the detachment with that of the intact retina adjoining it. The blood-vessels appear smaller and are dark and tortuous. The presence of vitreous opacities may obscure the view of the fundus, in some cases necessitating careful taking of the visual field to determine the intact portions of the retina. In extensive separation the characteristic appearance is most marked near the periphery. In the early stages it may be detected anywhere in the eye-ground, but as the case progresses it sinks, and is usually found below the disk. When the separation becomes complete, or nearly so, the detached retina often assumes a funnel-shape, the apex being the papilla and the base the ora serrata, in which case the diagnosis may be made very easily by oblique illumination or even by the unaided eye. The detached portion appears as a number of bluish gray or greenish folds with white tops which project into the vitreous and possess considerable movement; the blood-vessels can be seen coursing over these folds and often becoming hidden in the retinal wrinkles. The tension is always low and the anterior chamber is deeper than normal, but externally the eye appears unaltered.

Diagnosis.—Sudden impairment of vision in one eye, affecting only a portion of the visual field, should always suggest this affection. If the detachment be in its incipiency, it may not have lost its red reflex, and the condition may escape the examiner's attention. Unless there is a distinct folding or floating of the affected area, it should usually be regarded as a swelling rather than a detachment.

Treatment.—The patient should be placed in a recumbent position with the eyes at absolute rest. The hot-pack and pilocarpine by increasing absorption have been advantageously administered; potassium iodide and salicylate of strontium in moderate doses, long continued, have also proved of benefit. If these measures are found to be valueless, puncture of the sclerotic beneath the curtain and the withdrawal of the subretinal fluid should be advised. An iridectomy together with the use of eserine has also been advocated. The subconjunctival injection of saline solutions of varying strengths has been attended by temporary relief and deserves a thorough trial. The fact that new procedures for the control of this condition are constantly being brought forward is in itself sufficient proof that a satisfactory form of treatment has not yet been devised.

Prognosis.—This is very unfavourable. In cases due to disease of the vitreous, while detachment may be arrested, there is almost certain to be a recurrence of the condition, since no treatment has as yet been found to successfully combat this causal disease. There is a better chance to preserve the integrity of the eyeball in idiopathic cases, even though sight cannot be saved. Spontaneous cure is an occasional termination. Such a case recently came under the author's observation at the Medico-Chirurgical Hospital.

TUMOURS OF THE RETINA

Glioma.—Glioma, or as it is sometimes termed gliosarcoma, is the only malignant growth encountered in the retina. It always begins in childhood, and is occasionally congenital. Most cases begin before the third year. One eye alone is usually involved, but the affection may be bilateral.

The tumour is regarded by some authorities as an endothelioma of the retina. Its cells are of various sizes and shapes, some of which resemble ganglion cells, while others are more cylindrical, representing the layer of rods and cones. They are arranged in long tubes and surround the blood-vessels. It takes its origin from one of the granular layers of the retina and rapidly increases in size. In its progress it may project inward into the vitreous or it may advance outward or backward, causing retinal separation.

Symptoms.—Blindness is the earliest symptom, but it is passed unnoticed by the parents on account of the age of the child. Attention is first attracted to the patient by the shining, yellowish white reflex (amaurotic cat's eye) behind the pupil. This is generally observed when the child is about two or three years old. In the early stages there is an entire absence of pain or inflammatory symptoms, but later as the condition progresses pain, tenderness, and redness become manifest. When these inflammatory symptoms make their appearance they are generally associated with an increased ocular tension, cloudiness of the cornea, etc. The lens remains clear, and through it the white or yellowish white surface of the tumour may be seen. If the condition is not treated the tumour grows rapidly, breaking through the eye in front, involving the optic nerve behind, and even invading the bones of the orbit. It may extend along the optic nerve to the brain and give metastasis to other organs, especially the liver. In a few cases the inflammatory symptoms include a severe iridocyclitis, which may end in diminished intra-ocular tension and partial shrinking of the eyeball; this has the effect of completely masking the original disease. This condition is known as cryptoglioma.

In the later stages the tumour perforates the eyeball and appears between the lids as a spongy bleeding mass which undergoes ulceration. This condition is known clinically as *ophthalmia fungosa.* Destruction of all adjoining structures with metastasis and subsequent death occur in the absence of treatment.

The history of a recent case of this character will be of interest in this connection. The patient, a boy two years of age, was brought to me May 19, 1903, with the history that six months previous the mother had noticed a peculiar white reflex in the eye. This was pronounced when I saw the case and the diagnosis of glioma was made. Enucleation was performed May 25, 1903. The specimen was prepared and examined by Dr. H. C. Goldberg, with the following report:

Macroscopic Appearance.—Measurements: Antero-posterior, 22.5 millimetres; horizontal meridional, 22.5 millimetres; vertical meridional, 22 millimetres. Cornea clear; aqueous cloudy; anterior chamber of normal depth; lens small and transparent; vitreous chamber filled with growth; vitreous is pushed upward and forward by the growth and lies posterior to lens, remaining portion of the vitreous degenerated; papilla divides the growth into two portions, each of which possesses a point of vascularity; the nerve is swollen and apparently involved by the growth.

Microscopic Appearance.—Cornea is normal; anterior chamber is filled with homogeneous exudate; the iris is crowded forward into the angle, obliterating it at the nasal side; the iris shows evidences of old inflammation, is united to the cornea, and is atrophic; the ciliary bodies are atrophic and infiltrated by glioma cells; the processes are lengthened apparently by traction; on the temporal side only four processes remain, and these are drawn into points, each of which is covered by a layer of columnar cells of the pars ciliaris; the pigment forms a narrow base line, and about half of the stroma remains; the lens is healthy; posterior to the lens is a fine granular exudate which represents the remains of the vitreous. It contains glioma cells, polynuclear leucocytes, and free pigment; the retina is detached forward, and is represented only by a few cells of the nuclear layers, a few degenerated fibres of the fibre layer, and a thickened internal limiting membrane that takes the nuclear stain deeply; a few blood-vessels with degenerated walls may also be observed; on the nasal side these changes in the retina are more pronounced; posterior to the retina the growth is found in various stages of retrograde metamorphosis; blood-vessels and blood-spaces containing blood and glioma cells are found throughout the tumour, the interfascicular interspaces of the sclera are open; the chorioid is atrophic anteriorly, and is invaded by the glioma posteriorly; the nerve-fibres are entirely atrophied and almost completely replaced by cells of the growth; the growth is very vascular and the processes of the cells are arranged around the blood-vessels in the form of the so-called perivascular rosettes; the lymph-spaces are infiltrated and the perineural vessels contain the characteristic glioma cells.

The patient was again brought to me July 28, 1903, with recurrence of the growth. Puffiness of the lids was noticed two weeks previously, and was temporarily reduced by hot compresses. The recurrent growth is now about the size of an orange. There is also slight systemic disturbance.

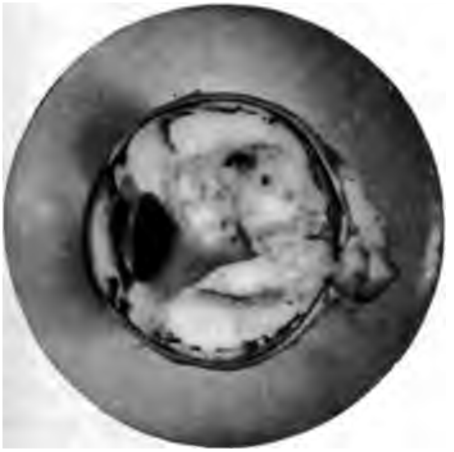

FIG. 106 – GLIOMA OF RETINA. (Author's case.)

Diagnosis.—A somewhat similar reflex is produced by the presence of a purulent exudate in the vitreous. This condition is known as *pseudoglioma*, and may be mistaken for glioma. The latter may be distinguished from the former by its rounded lobules, the presence of very small vessels on its surface, increase of ocular tension, the history, and the subsequent course. In pseudoglioma there is usually a history of previous suppurative chorioiditis, or retinitis, together with lowered tension and the presence of a white reflex from the fundus.

Treatment.—The only hope for saving the patient's life is to enucleate the eyeball, removing as much of the optic nerve as possible. It, of course, goes without saying that early operation increases the chances of saving life. The severed nerve should be examined microscopically, in order to determine whether the growth has extended beyond the point of section. If it is found that the malignant growth has extended beyond this point, glioma of the brain is to be feared, and the prognosis is extremely grave. The tissues of the orbital cavity must be removed, if they have become involved, and any suspicious spots in the walls of the orbit treated with zinc chloride or the cautery.

Prognosis.—This depends upon the character and location of the growth. If it be extending to the vitreous alone, enucleation of the eye will probably effect a permanent cure; if, however, the orbital tissues have been invaded, a recurrence is very likely to follow; if it is found that the tumour has extended beyond the orbital cavity, a lethal termination is certain, although operation may be performed to alleviate the pain. Recurrence in the other eye takes place in about 18 per cent of all cases.

In pseudoglioma the prognosis depends upon the irritability of the cyclitis; as a rule, the eye remains quiet for years, then suddenly develops a cyclitis or chorioiditis. It must be enucleated early. This condition is the result of a plastic cyclitis, and therefore it is liable to recur.

Cysticercus.—This very rare affection has been observed almost exclusively in Germany, in parts of which pork is eaten raw; it is of even rarer occurrence in this country. The cysticercus of the tænia solium may locate itself between the retina and chorioid, where it can be recognised with the ophthalmoscope as a sharply defined, bluish white body, with a yellowish margin. The cyst, which may be clear or purulent, presents a bright spot which corresponds to the head of the cysticercus. The parasite may move about, giving rise to considerable detachment of the retina, or may become encapsulated behind the retina; or it may burst into the vitreous, and finally, chronic iridocyclitis, with a total loss of sight and phthisis bulbi, is apt to ensue.

Treatment.—The only hope of saving the eye is by removal of the cyst; this can only be accomplished when it is favourably situated—i. e., when it is close to the equator of the eyeball. The author witnessed an operation for the removal of cysticercus in Vienna, but never in this country.

Prognosis.—The outlook is not very favourable.

CHAPTER XI

DISEASES OF THE OPTIC NERVE

Preliminary Considerations.—The description of the optic nerve, as ordinarily given, traces its fibres only as far back as the "optic chiasm" or "commisure," after which the bundles of nerve-fibres constitute the optic tract, and are described under that name. The optic nerve proper may be divided into three distinct portions: (1) The intra-ocular portion, which expands into the retina; (2) the orbital portion, extending from the globe of the eye to the optic foramen; and (3) the intracranial portion, which lies between the optic foramen and the optic chiasm. It is important to consider these portions as morbid processes, each being accompanied by separate and distinct symptoms.

The point at which the optic nerve pierces the fibrous and vascular tunics to become the intra-ocular portion is situated a little to the inner side of the posterior pole of the globe. The sheaths of the nerve correspond to and are continuous with the membranes of the brain, becoming fused with the outer layers of the sclera as the nerve enters the eyeball. The inner layers of the sclera span the opening for the nerve and form a sieve-like arrangement known as the *lamina cribrosa*, through which the various bundles of the nerve pass. A central opening larger than the rest transmits the central artery and vein of the retina, and is known as the "*porous opticus*." As the fibres of the nerve pass through this cribriform arrangement of the sclera they lose their medullary sheaths and become transparent. Occasionally under normal conditions this does not occur, and the medullated nerve-fibres are continued into the retina, forming opaque masses near the optic disk when viewed through the ophthalmoscope. As the fibres of the nerve separate from each other at different levels before expanding into the retina, a funnel-shaped depression in the centre of the disk results, termed the "physiological excavation." The terminations of the optic nerve in the retina are the neurons which are contained in the ganglion cell layer in close contact with the layer of rods and cones.

The orbital portion of the nerve is more or less folded upon itself, or **S**-shaped, to allow free movement of the eyeball in all

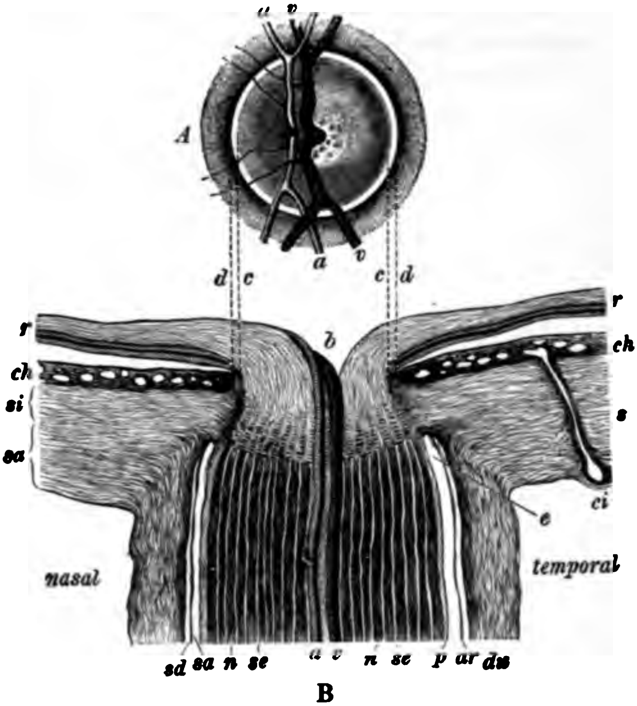

FIG. 107.—HEAD OF THE OPTIC NERVE.

A. *Ophthalmoscopic View.* Somewhat to the inner side of the centre of the papilla the central artery rises from below, and to the temporal side of it rises the central vein. At the temporal side of the latter lies the small physiological excavation with the gray stippling of the lamina cribrosa. The papilla is encircled by the light scleral ring (between *c* and *d*), and the dark chorioïdal ring at *d*.

B. *Longitudinal Section through the Head of the Optic Nerve.* Magnified 14+1.—The trunk of the nerve up to the lamina cribrosa consists of medullated nerve-fibres, *n*. The clear interspaces, *se*, separating them represent the septa composed of connective tissue. The nerve trunk is enveloped by the sheath of pia mater, *p*, the arachnoid sheath, *ar*, and the sheath of dura mater, *du*. There is a free interspace remaining between the sheaths, consisting of the subdural space, *sd*, and the subarachnoid space, *sa*. Both spaces have a blind ending in the sclera at *e*. The sheath of dura mater passes into the external layers, *so*, of the sclera, the sheath of pia mater into the internal layers, *si*, which latter extend as the lamina cribrosa transversely through the optic nerve. The nerve is represented in front of the lamina as of light colour, because here it consists of non-medullated and hence transparent nerve fibres. The optic nerve spreads out upon the retina, *r*, in such a way that in its centre there is produced a funnel-shaped depression, the vascular funnel, *b*, on whose inner wall the central artery, *a*, and the central vein, *v*, ascend. The chorioïd, *ch*, shows a transverse section of its numerous blood-vessels, and towards the retina a dark line, the pigment epithelium; next the margin of the foramen for the optic nerve and corresponding to the situation of the chorioidal ring, the chorioid is more darkly pigmented. *ci* is a posterior short ciliary artery which reaches the chorioid through the sclera.

directions without tension upon the nerve. The nerve is composed of bundles of medullated fibres, supported by a network of fibrous tissue, between which are lymphoid spaces. The membranes or sheaths of the nerve are three in number, and from without inward are: the dural, arachnoid, and pial sheaths. The lymph-spaces common to these membranes, when surrounding the brain, are also present in this situation, and communicate with the more minute spaces in the nerve itself. The lymph-space between the dural and pial sheath is known as the intervaginal space, and is divided into two portions by the arachnoid sheath. Anteriorly this space terminates blindly, where the sclera and nerve-sheaths unite, and posteriorly it is continuous with similar lymph-spaces between the meninges of the brain. A short distance behind the globe of the eye the optic nerve is pierced by the central artery and vein of the retina. The intracranial portion is that which extends from the optic foramen to the commissure. It has the same sheaths and lymph-spaces, and is liable to considerable compression by the bony wall of the orbit in the event of its becoming the seat of inflammation.

The optic nerves now meet and cross each other, forming the optic chiasm or commissure, through which the fibres may be traced to the optic tract of the opposite side, and from thence to their central origin. In order to obtain a clear conception of the relation of the chiasm to the various pathological conditions of the optic nerve, it is necessary to follow the course of the optic tract from its origin in the brain, until, by its union with the tract of the opposite side, the chiasm is formed.

The optic tracts may be traced to various nuclei in the cerebral cortex in the neighbourhood of the mesial surface of the occipital lobe, the cuneus, and the region of the calcarine fissure. Each optic tract is divided into two bands shortly after its origin in the brain. One of these arises from the stratum opticum of the corpora quadrigemina and emerges from the nates of this body as the anterior brachium. It then passes obliquely outward between the inner and outer geniculate bodies. The second band takes its origin from the optic thalamus, and after passing through the inner geniculate body, from which it derives some fibres, joins with the first band. The result of this union is a flat band which passes obliquely across the under surface of the crus cerebri, to the anterior margin of which it becomes attached. The shape of the tract is now altered, becoming more cylindrical in character. It then passes forward, being re-enforced by fibres from the tuber cinereum and the lamina cinerea.

The tracts from either side now advance towards each other and cross, forming the optic commissure, a quadrilateral body, which rests upon the optic groove of the sphenoid bone. Partial decussation of the fibres then takes place—the fibres on the inner margin being continued from one side of the brain to the other, having no connection with the optic nerves, the fibres on the outer margin are continued on into the optic nerve of the same side, and the central fibres cross, so that fibres from one optic tract may be traced into the optic nerve of the opposite side. In the anterior portion of the chiasm a few fibres serve to connect the optic nerves alone, having no connection with the optic tracts at all. Bernheimer has demonstrated anatomically the existence of uncrossed optic nerve-fibres in man by the microscopic examination of twenty sections through the chiasm of a child with bilateral microphthal-

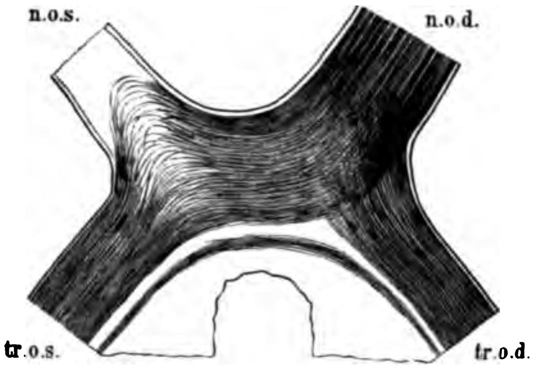

FIG. 108.—CHIASM IN ATROPHY OF THE LEFT OPTIC NERVE. Magnified 3×1.

The specimen is from a man, sixty-five years of age, whose left eye had been blind from childhood because of a total staphyloma of the cornea, due probably to blennorrhœa neonatorum. The cut represents a section passing through the chiasm in the horizontal plane, and stained with hæmotoxylin by Weigert's method, so that the normal (medullated) nerve fibres look black, while the atrophic fibres are unstained. The left optic nerve, *n.o.s.*, is completely atrophic, being both unstained and also considerably narrower than the right, *n.o.d.* The greater part of the fibres composing the latter pass transversely through the chiasm into the left optic tract, *tr.o.s.* On their way they make a looplike bend into the left optic nerve. The smaller portion of the fibres of the right optic nerve remains on the right side of the chiasm, and passes over into the right optic tract, *tr.o.d.* Since the non-decussating fibres are less numerous than the decussating, the right track appears somewhat narrower in cross section than the left. The bundle of nerve fibres running in a curve along the posterior border of the chiasm, and separated from it by a light-coloured zone, is Gudden's commissure (or commissura inferior) which contains no optic-nerve fibres.

mos. This confutes Kölliker's statement that the centripetal fibres arising from the retina in man, dog, cat, and rabbit cross completely.

From the arrangement of the fibres in the commissure it may be easily seen that the left half of each visual field is controlled by the right optic tract and centres of the right side, and that the right half of each visual field receives its innervation from the left optic tract and corresponding cerebral centres. To avoid confusion, it may be here stated that the right half of the visual field corresponds to the left half of the retina of each eye, and *vice versa.*

The "macula lutea" is not bisected by this arrangement, as would be supposed, as it is supplied by fibres from each optic tract. Bearing the knowledge of the partial decussation of the fibres in mind, the character of any existing blindness, and the situation of its cause, may be easily ascertained. For instance, monocular blindness arising from a lesion of the nerve is due to some morbid process situated anterior to the optic commissure; blindness limited to corresponding sides of the visual field (homonymous hemianopsia) results from disease of the optic tract or central nuclei on the side opposite to that of the blindness; blindness limited to the macular region (central scotoma) is due to some pathological process in the bundle of nerve-fibres supplying the macula lutea; blindness on both temporal or nasal sides of the visual field (bitemporal or binasal hemianopsia) finds its cause in disease of the chiasm.

The reaction of the pupils, when light is thrown upon the various parts of the retina, is also of great importance in this connection. If one tract alone is affected the pupils respond to light thrown upon the intact portions of the retina, but fail to do so when the light is directed towards the blind areas (Wernicke's pupillary reaction sign). In such cases the situation of the lesion is below the corpora quadrigemina. Response of the pupils to light thrown upon both sides of the retina in cases of blindness indicates that the lesion is situated higher up in the course of the fibres than the corpora quadrigemina.

As the function of the optic nerve is to conduct impulses from the retina to the brain that result in vision, any disease or injury of that structure will result in impairment of vision and the visual field. The visual field is the extent or space through which it is possible to discern objects when the line of vision is directed towards one point. Each eye has a field of vision peculiar to itself, but when both eyes are combined the visual fields overlap

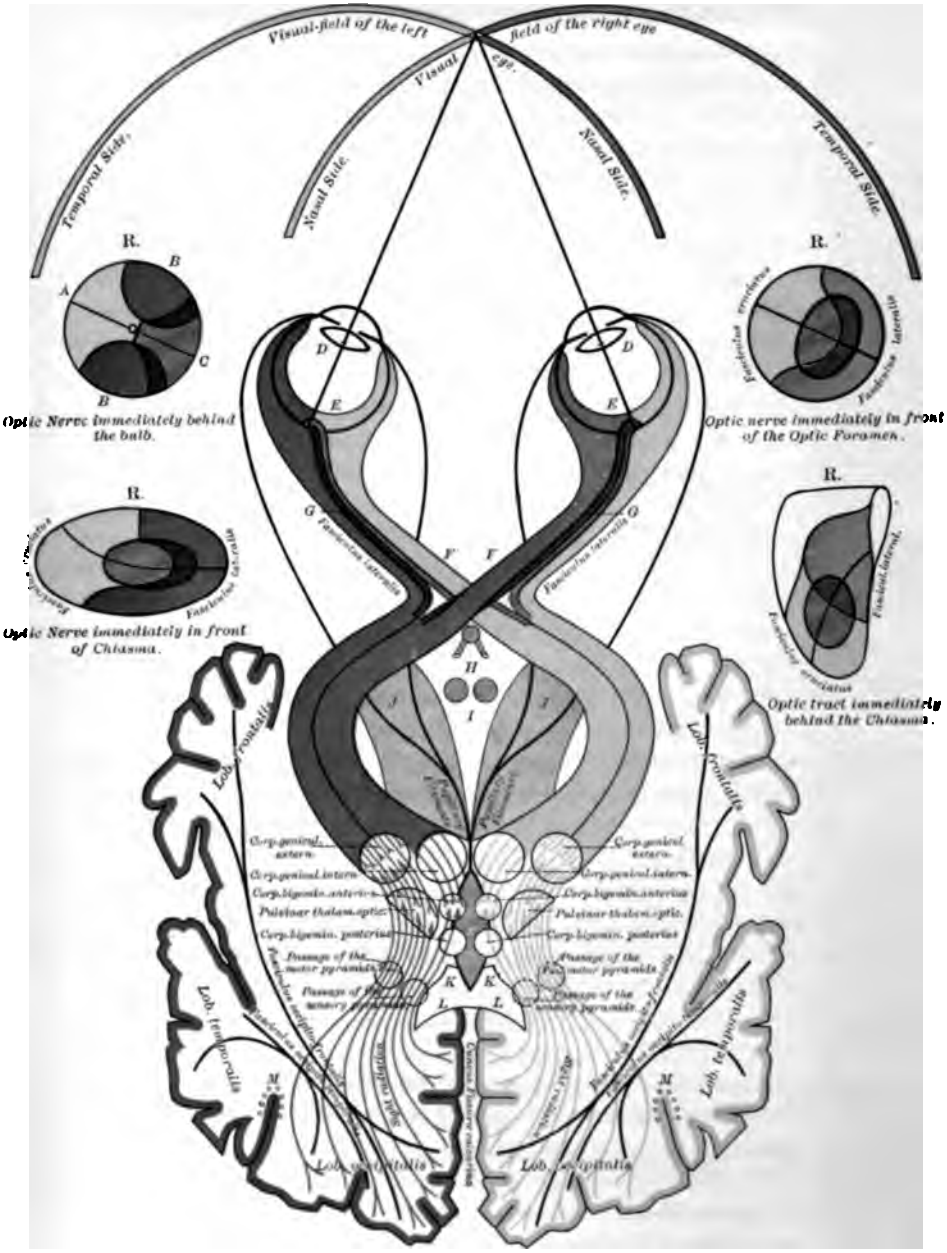

PLATE IV.—DIAGRAM OF OPTIC NERVES SHOWING SIGHT PLANES.

and form a common field of [illegible] peripheral and central. All [illegible] formed by the macula lutea a[illegible] vision occurs as the peripher[illegible] merely protective in character. [illegible] be determined roughly by [illegible] tance in all meridians until it is perceived: but a more accurate method of obtaining the same result is by means of the perimeter.

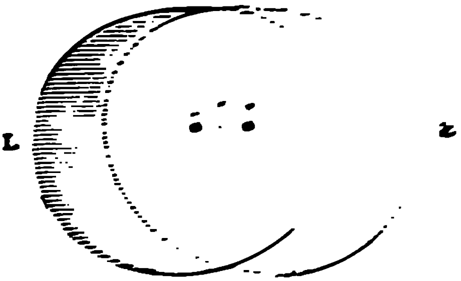

Fig. [illegible]

[illegible]

The perimeter is an instrument provided with an arm which represents a portion of the arc of a circle. This arc is graded in degrees and can be rotated, [illegible] central portion being marked by a white spot which corresponds to the fixation point. A small square or circle containing coloured pieces of paper varying in size from 5 to 10 millimetres, [illegible] visible at a time, is made [illegible] periphery towards the [illegible] meridians. The degree [illegible] object is perceived [illegible] this purpose. The [illegible] ated about 12 inches [illegible] be tested separately. [illegible] tained, and normally [illegible] side, 60 degrees upward [illegible] ward, being limited [illegible] eyes of the face. The [illegible] field in this [illegible]

A blind spot extending [illegible]

and form a common field of vision. Vision may be divided into peripheral and central. All acute vision is central and is performed by the macula lutea alone. A diminution in the acuity of vision occurs as the periphery is reached, at which point it is merely protective in character. The area of the visual field may be determined roughly by bringing the hand in from infinite distance in all meridians until it is perceived; but a more accurate method of obtaining the same result is by means of the perimeter.

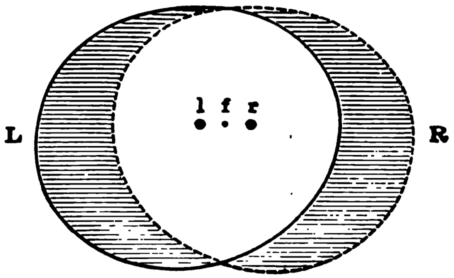

Fig. 109.—Binocular Field of Vision. (After Möser.)

The undotted line, *L*, bounds the visual field of the left eye, the dotted line, *R*, the visual field of the right. The median portion of the two visual fields overlap to an extent shown by the surface left white. This is, accordingly, the binocular field of vision, all objects in which are seen by both eyes at the same time. In its centre lies the point of fixation, *f*, and at either side of the latter the blind spots, *r* and *l*, of the right and left eye. Adjoining either side of the binocular field of vision are the temporal divisions of the two visual fields (the shaded areas in the figure), objects in which are seen with one eye alone.

The perimeter is an instrument provided with an arm which represents a portion of the arc of a circle. This arc is graded in degrees and can be rotated, its central portion being marked by a white spot which corresponds to the fixation point. A small square or circle containing coloured pieces of paper varying in size from 5 to 10 millimetres, so arranged that only one piece is visible at a time, is made to travel on the arm from the extreme periphery towards the centre until perceived through all the meridians. The degree in each meridian at which the travelling object is perceived is noted upon a chart especially provided for this purpose. The patient's chin should be placed upon a rest situated about 12 inches from the fixation point, and each eye should be tested separately. The field for white should be first ascertained, and normally this extends about 95 degrees to the temporal side, 60 degrees upward, 50 degrees inward, and 80 degrees downward, being influenced greatly by the extent of the bony processes of the face. The fields for blue, red, and green follow the white field in this order, each being more contracted than its predecessor.

A blind spot extending over 5 degrees is detected when each eye is tested separately, about 15 degrees to the temporal side of the fixation point, and corresponds to the entrance of the optic nerve. In the combined field these are effaced as a result of the overlapping of the individual fields.

Campimetry is sometimes employed in cases of extremely low vision. A blackboard is marked off in degrees and a lighted candle is placed at the fixation point. A second lighted candle is then brought in from the periphery, through all the meridians, and the point at which it is perceived is marked on the board. The light sense is determined also by this test.

Blind spots that occur in the visual field as the result of disease of the nerve are known as scotomata. They may be positive when the patient is conscious of their presence by the black spots in the visual field, or they may be negative when they can be detected only by the perimeter. Scotomas may also be relative or absolute, according to the degree to which vision is lost. According to their situation they may be central, paracentral, or disseminated, and according to their size they may be large, small, and irregular.

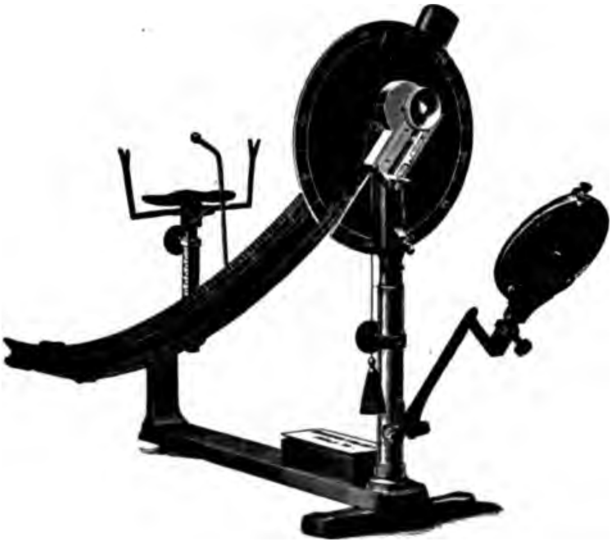

FIG. 110.—MCHARDY SELF-RECORDING PERIMETER.

Anomalous Conditions of the Optic Nerve.—Perhaps the most frequent anomaly is that already referred to as opaque nerve-fibres. They may be present in one or both eyes, and appear as a dull white or bluish patch at the upper or lower margins of the disk, terminating in radiations into the retina. It is seldom found at the nasal or temporal side of the optic nerve-head, and occasions no disturbance of vision, with the exception of an increase in the extent of the blind spot.

Coloboma of the disk consists in a failure of the two segments of the optic nerve to properly unite in the latter months of embryonal life, and is usually a part of a general coloboma involving the iris, retina, and chorioid, but may exist alone. Its presence causes an enlargement in the appearance of the head of the optic nerve, and an excavation extending downward and backward may be discerned. The pigment at the nerve borders is unusually excessive in amount, and the depth of the excavation causes an apparent distortion and uneven division of the retinal vessels. The most rare anomaly of the optic nerve is its complete absence. Spiller (Brain,

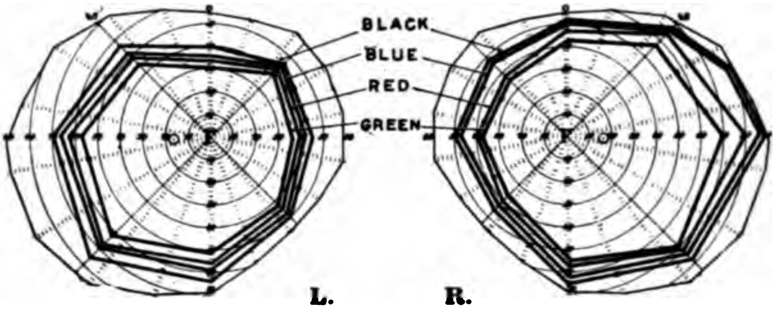

Fig. 111.—Normal Visual Fields.

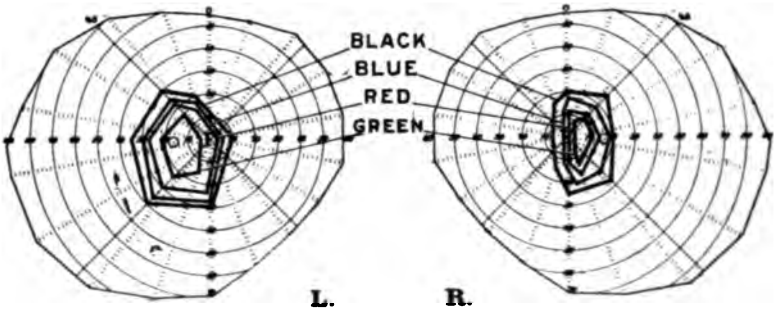

Fig. 112.—Visual Fields in Glaucoma Simplex.

1902, page 631) has observed a case in which the eyeballs, optic foramina, optic nerves, chiasm, optic tracts, and external geniculate body were absent. The posterior portion of each thalamus was rounded and larger than one would expect to find. The patient was a helpless idiot of twenty-two years of age afflicted with paraplegia.

The shape of the optic disk may undergo variations. Usually it is round or oval with the long axis at 90, and most of the distortions seen by the aid of the ophthalmoscope are due to errors of refraction. Occasionally a true distortion will be encountered.

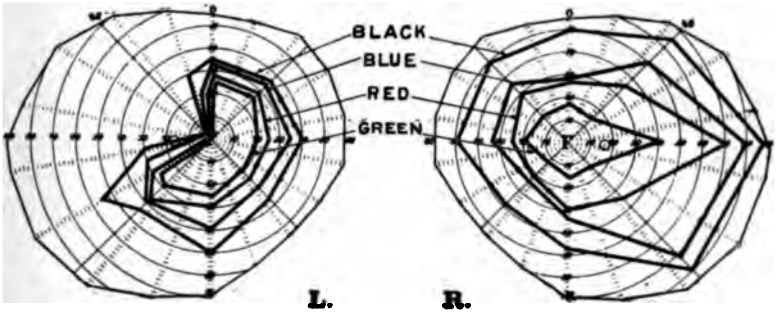

FIG. 113.—VISUAL FIELDS IN GRAY ATROPHY OF OPTIC NERVE.

An indistinctness of the surface of the disk and its blood-vessels is sometimes present in the absence of any disease of the nerve or error of refraction due to glistening patches of tissue or a hazy membrane in this situation. This is a rare condition, and is attributed to the incomplete disappearance of the hyaloid artery.

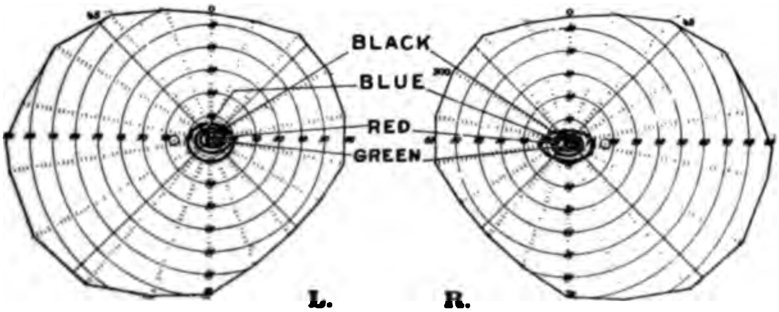

FIG. 114.—VISUAL FIELDS IN RETINITIS PIGMENTOSA.

The borders of the disk permit of normal variation in the pigment and the scleral ring, the latter often assuming a crescentic shape at the outer margin.

The principal pathological conditions to which the optic nerve is liable are congestion, anæmia, inflammation, atrophy, and morbid growths.

Congestion of the optic disk accompanies many abnormal conditions of the eye, the principal of which are probably errors of refraction. It precedes true inflammation of the nerve, and is associated with inflammation of adjacent structures of the eye. It may also arise from a general plethoric condition of the body, cerebral congestion, and conditions of the thoracic and abdominal viscera that induce disturbances of the peripheral circulation. It is manifested by increased redness of a brick-dust hue, blurring of

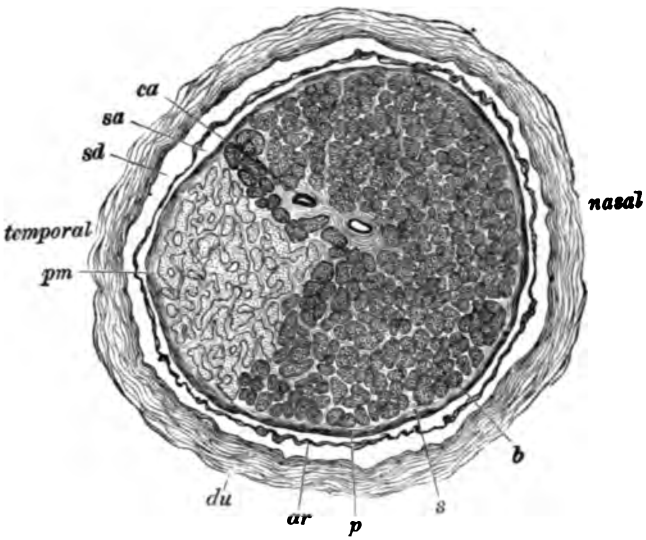

FIG. 115.—CROSS SECTION OF THE OPTIC NERVE, WITH ATROPHY OF THE PAPILLO-MACULAR BUNDLE (SECTION MADE 4 MM. BEHIND THE EYEBALL). Magnified 15 × 1.

The optic nerve is enveloped in the dural sheath, *du*, the arachnoid sheath, *ar*, and the pia-sheath, *p*. Between the first and second is found the subdural space, *sd*; between the second and third, the subarachnoid space, *sa*. On the outer and upper side of the centre of the section is seen the central artery, *ca*; and more centrally is seen the central vein. These are surrounded by the cross sections of the nerve bundles, *b*, which are separated from each other by the septa, *s*, of connective tissue. At the temporal side, a wedge shaped segment, *pm*, is distinguished from the rest of the cross section of the nerve by its paler colour. This represents the atrophic papillo-macular bundle. Within the confines of it the cross sections of the nerve bundles are narrower and the septa of connective tissue are correspondingly broader.

the margins of the disk, and fulness of the veins. On account of its resemblance to optic neuritis it has been termed "spurious optic neuritis." The treatment is simple and effective. The correction of any ametropia present usually suffices to relieve the condition.

Anæmia of the optic nerve-head is less frequent than the opposite condition and is less often recognised. Although present in all forms of anæmia and chlorosis, it is most marked in obstruction of the local circulation by the presence of an embolus in the central retinal artery. The treatment in such cases is of very little avail.

Inflammation of the optic nerve, or optic neuritis, may be situated in the head of the nerve constituting papillitis or choked disk, or it may be posterior to the globe, to which condition the term retrobulbar neuritis is applied.

PAPILLITIS

Inflammation of the optic nerve characterized by pathological changes confined to the head of the nerve, causing a condition known as choked disk, owing to the appearance presented by the optic disk when so affected.

Causes.—The principal causes are diseases of the brain or meninges, syphilis, constitutional disorders, anæmia, disturbances of menstruation, lactation, pregnancy, lead-poisoning, heredity, and diseases or tumours of the orbit or neighbouring structures. The most frequent cause is brain tumour, of which choked disk is often the first distinctive symptom. The other symptoms, such as headache, vertigo, vomiting without nausea, pressure symptoms, and psychic disturbances, serve to confirm the diagnosis in such a case. Although choked disk nearly always points to brain tumour, it by no means serves to localize it. In some cases the changes in the macular region suggest the possibility of albuminuric retinitis. Conditions of the brain other than tumours, such as meningitis, abscess, and hydrocephalus, may also induce optic neuritis. A series of cases have been reported by St. Clair Thompson in which a persistent discharge from the nose of a fluid resembling cerebrospinal fluid was associated with optic neuritis. The symptoms of cerebral pressure were present, and in all probability these were cases of internal hydrocephalus, the fluid finding its way from the third ventricle through the cribriform plate of the ethmoid bone to the nose. Paresis, locomotor ataxia, and multiple sclerosis are often associated with optic neuritis. C. O. Hawthorne (British Medical Journal, February 8, 1902) has observed a case of double optic neuritis in a chlorotic patient directly traceable to intracranial thrombosis.

The constitutional affections of ætiological significance in this connection are syphilis and tuberculosis, particularly those manifestations that occur within the cranium. Among the less frequent causes may be mentioned measles, scarlet fever, diphtheria, influenza, rheumatism, nephritis, arteriosclerosis, lead-poisoning, sunstroke, fracture of the skull, and exposure to cold. It is occasionally congenital, and may arise without obvious cause.

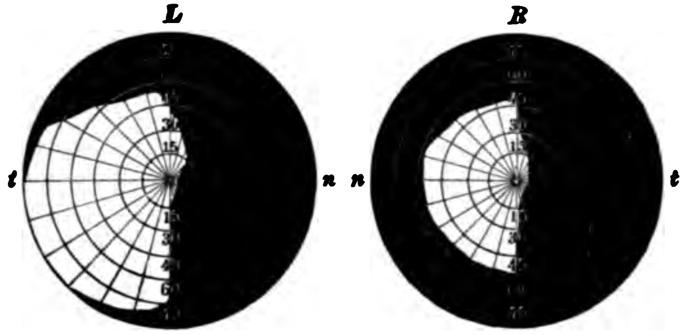

FIG. 116.—HOMONYMOUS HEMIOPIA. (After Schweigger.)

The areas which have been left white correspond to the left halves of the visual fields, *R* and *L* of the right and left eye, which are still intact : *t*, temporal ; *n*, nasal side.

Most cases are bilateral in character, but unilateral papillitis may follow inflammatory conditions or injury of the orbit or adjacent sinuses, such as disease of the sphenoid, ethmoid, frontal, or maxillary sinus, tumours of the orbit or the nerve itself, and panophthalmitis. Unilateral choked disk has, however, been observed in six well-attested cases of cerebral tumour.

Varieties.—Two clinical varieties have been described—choked disk and descending optic neuritis. Choked disk is distinguished by marked swelling and enlargement of the disk alone with considerable engorgement of the veins, while descending optic neuritis is characterized by more exudation and extension into the surrounding retina, less swelling of the disk and changes in the blood-vessels. It is often difficult to separate these varieties on account of the great frequency of transitional forms. A combination of retinitis and papillitis is not uncommon and constitutes neuroretinitis. As regards duration, papillitis may be acute or chronic, the latter being most common. It may also be unilateral or bilateral.

Symptoms.—Vision undergoes marked alterations, depending upon the severity of the inflammation, and blindness sometimes supervenes, but occasionally it is unaffected. The visual field is considerably contracted, particularly at the periphery. The contraction for colour is especially well marked, and the blind spot is larger than normal. Hemiopia and scotomata may be present, but at no time is pain a symptom of optic neuritis. There are no external manifestations.

Ophthalmoscopic Appearances.—The head of the optic nerve seems swollen and appears to project forward. The term "woolly," used in this connection, is most descriptive. It is larger than normal and of a whitish or grayish colour, and often marked by striæ upon its surface. The normal striation at the edge of the disk is considerably exaggerated. Hæmorrhages and white spots upon the disk are not uncommon. The margins of the nerve are considerably blurred, so that no definition of outline is present, the location of the nerve being determined by the convergence of the retinal blood-vessels, which seem to come forward as they leave the disk. The physiological cup is oblìterated. The veins are greatly distended and tortuous, often to a marked degree, and the arteries may be smaller than normal, and seem to suffer interruptions in their course, owing to the swelling of the nerve. The retina in the immediate neighbourhood is congested and œdematous, and often

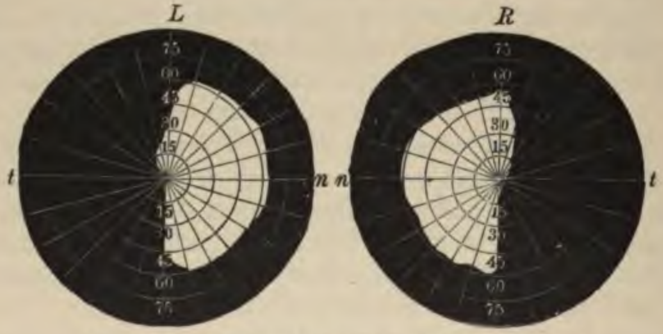

FIG. 117.—TEMPORAL HEMIOPIA. (After Schweigger.)

The areas left white correspond to the nasal halves of the visual fields, *R* and *L*, of the right and left eye, which are still intact: *t*, temporal; *n*, nasal side.

the site of hæmorrhage in various stages of absorption. This appearance is best seen in neuroretinitis.

Pathology.—As in all other inflammations, there is congestion with later permanent dilatation of the blood-vessels and exudation of leucocytes. The incidental swelling takes place in the direction of least resistance, causing distention of the intervaginal lymph-space and projection forward of the head of the nerve with œdema and hæmorrhage. As a termination, connective tissue forms which undergoes contraction, giving rise to optic atrophy. The exact manner in which cerebral and other conditions bring about optic neuritis has not been determined. It is probable that in cases due to brain tumours the increased intracranial pressure influences the pressure within the intervaginal lymph-space and induces swelling of the optic nerve, while in cases due to meningitis there is an extension of the inflammation by continuity and contiguity of structure. Papillitis, however, does not attend all forms of increased intracranial pressure, as is shown in cerebral hæmorrhage and intracranial aneurysm. It has also been maintained that irritating substances in the lymph and blood streams have been brought to the nerve and induce reactionary changes in the form of inflammation. It is most likely that a combination of these processes is present in all forms of optic neuritis, but in varying proportions, according to the cause. Micro-organisms by direct or indirect contact produce the inflammation upon an optic nerve the vitality of which has been reduced by alterations in nutrition.

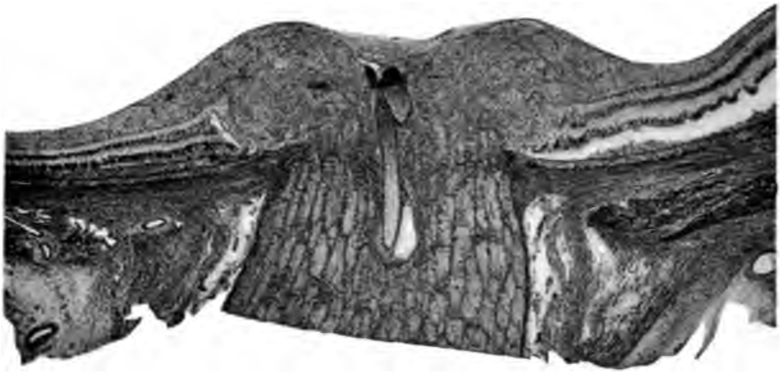

FIG. 118.—OPTIC NEURITIS. (Longitudinal Section.)

Diagnosis.—In the early stages papillitis may be confused with conditions resulting from eye-strain, and in the later stages with albuminuric retinitis. The distinguishing features of the disease are its localization to the disk, obscuration of the disk-margins, obliteration of the physiological cup, contraction of the visual fields, and the change in the calibre of the blood-vessels.

Prognosis.—The ultimate outlook for vision is always unfavourable, although perfect vision may be retained for months in marked cases. It depends primarily upon the degree of inflammation, and secondarily upon the extent of the subsequent atrophy of the nerve. Vision is always impaired and may be lost entirely. A fatal termination may occur in those cases of cerebral origin. Recurrences are not uncommon, but seldom take place in cases due to brain affections, when the primary condition has been permanently relieved.

Treatment.—In those cases in which a brain tumour can be definitely localized it should be removed by trephining, after a careful trial with internal medicine. The predominance of syphilitic lesions in the brain would indicate the free administration of mercury and the iodides. In the absence of history or other signs of syphilis benefit often follows the use of such drugs. Other incidental or causal conditions should receive the same treatment as under other circumstances. Dark glasses should be worn, and the patient should abstain from using the eyes as much as possible. In monolateral cases operative measures directed towards the causal disease are necessary, and sometimes enucleation is required.

RETROBULBAR NEURITIS

Inflammation of the orbital portion of the optic nerve. It may be acute or chronic.

Acute retrobulbar neuritis is an infrequent condition, and is nearly always unilateral in character.

Causes.—The most important ætiological factors are exposure to cold, rheumatism, syphilis, the poisons of diphtheria, scarlet fever, malaria, etc., alcoholic intoxication, and the extension of inflammation from adjacent structures. Intestinal parasites may also induce this condition. Disseminated sclerosis is often associated with it.

Symptoms.—The most prominent manifestation is the rapid and progressive impairment of vision, inducing, not uncommonly, complete or partial blindness in the course of a week. The patient complains of neuralgic pains in the head, face, and eyeball that are intensified by ocular movements. Tenderness may be elicited by pressure upon the globe of the eye. The external appearance of the eye is in no manner altered. Ophthalmoscopic examination usually shows no distinctive signs. The borders of the disk may be hazy, and the vessels may be altered in character. The disease runs an acute course, terminating in one or two months. The vision may return to normal or it may remain considerably impaired. The inflammation involves the papillo-macular bundle of fibres in the optic nerve, giving rise to central scotomata and alterations in the visual field.

Treatment. — As some form of acute toxæmia is the usual cause, free purgation and diaphoresis should be promptly instituted. The salicylates, iodides, mercury, pilocarpine, and strychnine are particularly indicated. Efforts should be made to ascertain the exciting cause, and to remove it if possible.

Chronic retrobulbar neuritis is a common affection, and usually attacks both eyes at the same time.

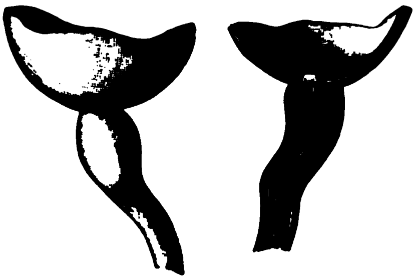

FIG. 119.—RETROBULBAR NEURITIS.

Upon the left side is seen the ampulliform swelling of the optic nerve in its anterior portion. Upon the right are represented the relations as seen after making a longitudinal section of the nerve. One can see how the swelling of the nerve is caused by the distention of the outer sheath, which is separated a good way from the trunk of the nerve; and can recognise the projection of the papilla above the level of the retina.

Causes.—The excessive use of alcohol and tobacco for long periods is the most common cause, and the condition is most frequent in middle-aged men. The continued absorption of other poisons, such as iodoform, lead, arsenic, wood alcohol, bisulphide of carbon, stramonium, cannabis indica, chloral, opium, and dinitrobenzol, also produce the affection. Diseases, such as diabetes, syphilis, and auto-infection from the intestinal tract, may give rise to this form of optic neuritis. Diseases of the nervous system, such as disseminated sclerosis, may also be attended by it.

Symptoms.—The visual acuity becomes impaired, being best in a dull light or towards evening. The field of vision undergoes no peripheral alteration, but central scotomata, particularly for red and green, are well marked. These scotomata are usually relative, but may be absolute in character. Ophthalmoscopic examination reveals nothing abnormal in the early stages, but as the condition advances pallor of the disk towards the temporal side will be noticed.

The course of this affection is very slow and prolonged, increasing proportionately with the continuance of the poison. Gradual but permanent improvement follows the withdrawal of the cause in most cases, but in severe types of the affection diminution of the visual field and central scotomata may persist. The nature of the disease is largely interstitial, limiting itself to the axial fibres of the nerve or those supplying the macular region, thus accounting for the presence of central blind spots.

Treatment.—The withdrawal of the drug causing this condition is the first indication. Stimulation by means of good food, fresh air, outdoor exercise, and drugs, such as strychnine and nux vomica, is indispensable. Dark glasses should be worn constantly, and the use of the eyes should be reduced to a minimum.

OPTIC ATROPHY

A diminution in the size with a corresponding diminution in the function of the optic nerve due to the wasting of its fibres and their replacement by connective tissue. It may occur as a primary affection, or it may be secondary to some other disease of the optic nerve or the eye.

Primary optic atrophy is also known as gray degeneration of the nerve, and is progressive in character, being unassociated with any previous inflammation of the nerve. The ophthalmoscopic appearance presented by it consists in a sharply defined disk of a white or grayish or bluish-white colour. The margins are regular, and the papilla is smaller than usual. The minute blood-vessels normally present upon the disk are entirely absent. A saucer-shaped depression is frequently seen upon the head of the nerve which resembles somewhat the cup of glaucoma. The lamina cribrosa is plainly seen at the bottom of this excavation. The retinal vessels appear normal in some cases, but a diminution in the calibre of the arteries is not infrequent. One of the early signs is the undue broadening of the scleral ring.

Causes.—Primary optic atrophy usually follows some disease of the spinal cord or brain, the most frequent being locomotor ataxia. It has been observed in this disease that the early appearance of the optic atrophy seems to postpone the appearance of the prominent symptoms, such as the lightning-like pains and the ataxic manifestations. Among the other diseases of the nervous system associated with optic atrophy may be mentioned disseminated sclerosis, paresis, and tumours of the brain. Less frequently it may be attributed to syphilis, malaria, diabetes, acromegaly, heredity, and certain toxæmic conditions. It may arise from impaired nutrition of the nerve, due to a great variety of causes, or it may take place without any apparent cause whatever. It seldom appears before middle life, and its course is somewhat prolonged.

Secondary atrophy of the optic nerve occurs as a termination of inflammation of the nerve or adjacent ocular structures, and is often called postneuritic optic atrophy. Its origin is demonstrated by the connective tissue that remains upon the disk, giving it a dense white or grayish colour, and causing more or less irregularity of outline and obscuration of the margins. This connective tissue also serves to hide the lamina cribrosa and the smaller papillary vessels. The veins of the retina enlarge and become irregular and tortuous, while the arteries become contracted and are outlined by white streaks at their borders, due to the thickening of the perivascular lymph-sheaths. This form of optic atrophy also follows retinitis pigmentosa, and in such cases the disk presents a grayish-red or yellow waxy appearance.

Causes.—This form of optic atrophy always follows disease or injury of the nerve. It is a common sequel to papillitis and retrobulbar neuritis, and is the terminal stage of neuroretinitis, retinitis pigmentosa, and other degenerations of the retina. Embolism of the central artery of the retina, thrombosis of the veins, and glaucoma are also followed by it. Injury to the optic nerve induces atrophic changes also, but these seldom become manifest until after a period of several weeks.

Symptoms.—In both forms of optic atrophy the symptoms of the ocular trouble are alike. A marked reduction in the visual acuity is one of the first manifestations. The visual field becomes contracted, first for colours and later for form. The light sense becomes diminished and scotomata make their appearance. Colour blindness soon follows, being at first for green and later for red and blue. Although slow in its course, it tends to progress steadily and eventually terminates in blindness. In complete atrophy the pupil is dilated and the iris motionless.

Diagnosis.—The distinction between optic atrophy and other ocular affections is made largely by the use of the ophthalmoscope, but the examiner should be careful not to confuse the condition with variations in the colour of the disk as the result of congenital or senile changes. The differentiation of the two varieties of optic atrophy cannot always be made from the ophthalmoscopic picture alone, but frequently requires the consideration of the associated symptoms and history.

Treatment.—Therapeutic measures should always be directed towards the underlying cause, as the atrophy itself is not amenable to treatment. A course of mercury and the iodides and galvanism may be employed, but the results are not very encouraging. Occasionally the progress may be arrested by the administration of strychnine, nitroglycerin, and amyl nitrite. The subcutaneous injection of strychnine in this condition is highly recommended. Hot baths with leeches to the temple have been suggested, and drugs, such as antipyrine, silver nitrate, arsenic, santonine, and phosphorus have been employed.

Optic atrophy sometimes follows blows upon the back of the head and concussion of the brain. Instances of this infrequent condition have been reported by Mackenzie and others. In these cases the patient usually regains consciousness and returns to his daily routine to be attacked in from six weeks to three months with rapidly progressing loss of sight that terminates in incurable blindness. At this time ophthalmoscopic examination will show unmistakable signs of optic atrophy. The pathology of these cases is obscure, but it is probable that hæmorrhage occurs in the psychosensory centres in the cerebral cortex at the time of the accident, and the subsequent changes render these centres useless, and the optic nerve undergoes atrophy from disuse and lack of atrophic stimuli.

Three cases occurring in the experience of the author exemplify this condition very well. The first was a sailor who was struck by a belaying pin on board ship and was rendered unconscious. He was taken to a near-by hospital and was discharged when consciousness returned. At the end of a month his sight began to fail, and in three months from the injury blindness was complete in both eyes. Examination of the fundus oculi revealed well-marked optic atrophy in both eyes. The second case was that of a policeman who was struck in the occipital region with a brick while attempting to quell a riotous disturbance in the city. On being admitted to one of the city hospitals a diagnosis of cerebral concussion was made, and the patient was placed in bed until reaction occurred, after which he was discharged. He returned to his work, but was soon forced to abandon it on account of failing eyesight. This progressed rapidly and optic atrophy was diagnosed. Subsequently he became totally blind. The history of the third case is similar to that of the preceding. An Italian labourer while working upon a railroad was struck by a locomotive and rendered unconscious. His recovery from the injury was prompt, but the sight began to fail, and he became blind in about three months. The characteristics of optic atrophy were very distinct in each eye in this case.

Prognosis.—The ultimate termination of both forms of atrophy is complete or partial blindness. In secondary atrophy the blindness is proportionate to the degree of the primary inflammation.

TUMOURS OF THE OPTIC NERVE

Morbid growths occurring along the course of the optic nerve constitute a very rare condition, only about 130 cases of which have been recorded in literature. They may be found at any period of life, but occur with the greatest frequency before the age of twenty-one years. They are usually situated midway between the globe and the optic foramen.

Symptoms.—In all growths of the nerve there is slow and gradually increasing protrusion of the eyeball forward and outward, due to the increase in the orbital contents. Not infrequently the exophthalmos is so great that the eyelids fail to cover the cornea, and a suppurative inflammation of that structure is liable to occur from its exposure. The motion of the eye is not restricted by the growth and its centre of rotation is not displaced. The tumour is usually soft and may be palpable. Pressure upon it rarely gives rise to any pain. An optic neuritis follows sooner or later, and vision becomes markedly impaired. The pupil may become immobile in such cases, but the consensual reaction can always be obtained. The ophthalmoscope reveals nothing characteristic of the condition. The interference with the circulation in the nerve induces distention of the retinal veins and œdema of the papilla. With the occurrence of optic neuritis the usual alterations in the appearance of the disk take place, to be followed later by atrophic changes.

Varieties.—They may be myxosarcomas, endotheliomas, fibromas, gliomas, gummas, or tubercles. Metastatic carcinoma has been observed by Holden (Archives of Ophthalmology, September, 1902), but is extremely rare. Although blindness was present there were no abnormal changes visible in the fundus. The common growths are not malignant, in that they do not tend to recur or give metastasis in the internal viscera. In the early stage, at least, all are encapsulated by the fibrous sheath of the nerve.

Treatment.—This consists in removal of the tumour alone, enucleation of the eyeball and tumour, or exenteration of the orbit. Enucleation is perhaps the best mode of treatment, and should be preceded by a course of antisyphilitic treatment.

Hyaline or colloid growths may occur upon the head of the optic nerve. The appearance they present is particularly characteristic and consists in translucent masses or excrescences of a bluish-gray colour, more or less mulberry shaped, situated upon the disk, and in extensive cases obscuring its margins. They are vascular in origin, arising from the coats of the vessels of the disk, and in some cases from the lamina vitrea of the chorioid at the disk margins. The exact cause is unknown, but careful inquiry will serve to elicit a history of previous traumatism in most cases. Calcification of the nodules may eventually occur. The condition is seldom encountered in this country, but is comparatively frequent in Germany and Russia. There is no satisfactory treatment. The growths themselves have no serious significance unless an enormous size is attained. Intercurrent affections of the tunics of the eye may induce impairment of vision.

INJURIES OF THE OPTIC NERVE

The entrance of foreign bodies into the orbit may involve the optic nerve. In such cases atrophy follows but does not manifest itself at once. Rupture of the nerve is attended by immediate and complete blindness. Concussion of the nerve or hæmorrhages into its sheath may occur with suspension of vision more or less permanent. A great variety of injuries of the optic nerve may follow traumatism to the skull, particularly fracture of the base and of the orbit. Vision is lost and atrophy follows. In fracture of the base of the skull the hæmorrhage travels beneath the meninges and sheath of the nerve, causing loss of vision, and eventually, in the course of three or four days, appears beneath the conjunctiva. Hæmorrhage into the sheath of the nerve is also said to occur in those cases of sudden blindness following severe hæmorrhage, especially from the gastro-intestinal tract. The treatment, aside from those measures directed towards the underlying cause, is expectant in character.

VISUAL DISTURBANCE OF FUNCTIONAL ORIGIN

Amaurosis is the technical term for partial or complete blindness, while amblyopia is applied to diminution in visual acuity. In both conditions there is no discoverable structural change in the eye or optic nerve. As both terms indicate differences in degree only, the first is falling rapidly into disuse.

Congenital blindness is the earliest form encountered, and may be monocular or binocular. It is first noticed when the child begins to walk by its inability to avoid gross objects. If the condition is monocular, the blind eye will fail to fix and strabismus becomes manifest. In such cases nystagmus is a frequent accompaniment. Blindness at birth may also be due to some congenital malformation of the skull with imperfect development of the brain.

Blindness occurring twelve or eighteen months after birth is not infrequent in syphilitic children, in whom a basilar meningitis may be demonstrated. Microcephalus is the rule in such cases, and the patient usually remains an imbecile. Transient amaurosis is sometimes encountered as a sequel to infantile convulsions.

Amblyopia exanopsia is a variety in which some abnormal condition of the eye is the direct cause. This may be present at birth, but usually is not manifested until development of the child begins. It is dependent upon some high ametropic error in the affected eye. Usually anisometropia is present. The images are improperly focused, if at all, and the retina is deprived of the stimulation necessary for its development. In exceptional cases an excentric macula is formed. The coordination of the ocular muscles is impossible on account of the failure of the retina to send afferent impulses to the centres for muscle equilibrium, and strabismus results. It is also brought about in an effort to suppress the blurred image of the unsound eye. Correction of the ametropia and muscle exercises constitute the treatment.

In young children marked blepharospasm due to spasm of the orbicularis muscle incident to inflammatory diseases or errors of refraction is not infrequently attended by a temporary suspension of vision even after relaxation has occurred.

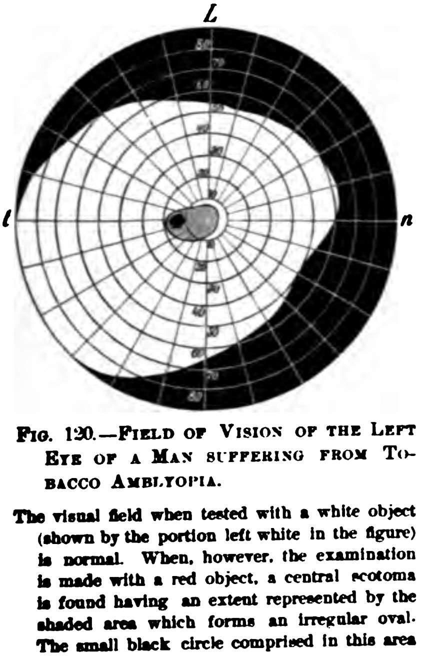

FIG. 120.—FIELD OF VISION OF THE LEFT EYE OF A MAN SUFFERING FROM TOBACCO AMBLYOPIA.

The visual field when tested with a white object (shown by the portion left white in the figure) is normal. When, however, the examination is made with a red object, a central scotoma is found having an extent represented by the shaded area which forms an irregular oval. The small black circle comprised in this area represents Mariotte's blind spot.

In youths of both sexes between the ages of eight and thirteen years there is sometimes found a temporary loss of vision independent of any structural change, and characterized by contraction of the visual field and a marked diminution in the central vision. It is not hysterical in nature, but results from some functional disturbance of the retina. The application of the constant current with the suspension of all close work bring about prompt restoration of vision.

Toxic Amblyopia.—Under this heading belong the cases that are due primarily to the presence of poisonous materials in the blood. These materials may be produced within the body, as uræmia, diabetes, and malaria, or they may be introduced from without, as in the case of tobacco, alcohol, and lead. In the early stages these poisons merely induce aberration of function, but in advanced stages retrobulbar neuritis (already described) and macular diseases may be demonstrated. In nearly all varieties of this condition there is diminution of central vision, with central scotoma, and different degrees of colour-blindness. The principal diseases that give rise to this condition by their toxins are uræmia, ptomaine poisoning, diabetes, malaria, and whooping-cough. The uræmic variety is most common during the kidney complication of scarlet fever and pregnancy. Its chief characteristic is the preservation of the pupillary reaction during the period in which vision is suspended. Headache, nausea, and convulsions are usually present. Diabetic amblyopia is distinguished by its marked tendency towards colour scotoma. The amblyopia of malaria is periodic in character, and is promptly relieved by the usual treatment for malaria. The poisons introduced from without that are potent factors in the production of amblyopia are alcohol, tobacco, lead, quarilla, quinine, santonin, arsenic, Jamaica ginger (methyl alcohol substituted for ethyl alcohol as a vehicle), nitrate of silver, cannabis indica, iodoform, chloral, and cocaine. The purely functional disturbance of vision is most manifest in the acute poisoning by these drugs. The treatment is obvious; withdrawal of the poison with rest and stimulation is curative.

A sudden diminution in vision may also follow concussion of brain or of the optic nerve itself. This is temporary in character, and results from injuries to the head, particularly in the occipital region, or blows upon the globe of the eye. Permanent blindness following such injuries indicates hæmorrhage, laceration, rupture, or other irreparable injury to the optic nerve or visual centres.

Temporary blindness may arise from excessive exposure to light from bright surfaces. Lightning flashes, calcium lights, snow, etc., often induce this condition. Excessive use of the eyes, with exhaustion of the retina, is also a cause. Exhaustion, such as follows great hæmorrhage, neurasthenia, excessive sexual intercourse, and diseases of the genitals, may be included as ætiologic factors.

Feigned Blindness.—This may be a part of a general manifestation of hysteria, or it may be the result of an attempt to avoid conscription, or to secure damages, or for some similar object.

Hysterical amblyopia is most common in young girls or young women, but may occur in males of sedentary habits. It is usually unilateral, and is characterized by contraction of the visual fields, often with reversal of the colour fields, varying degrees of diminished vision, crossed amblyopia, scotoma, and hemiopia. Among the other symptoms of which the patient complains may be included photophobia, flashes of light, blepharospasm, corneal anæsthesia, ptosis, etc. The intensity of these manifestations varies from time to time. Careful examinations at frequent intervals peripheral alteration, but central scotomata, particularly for red and green, are well marked. These scotomata are usually relative, but may be absolute in character. Ophthalmoscopic examination reveals nothing abnormal in the early stages, but as the condition advances pallor of the disk towards the temporal side will be noticed.

The course of this affection is very slow and prolonged, increasing proportionately with the continuance of the poison. Gradual but permanent improvement follows the withdrawal of the cause in most cases, but in severe types of the affection diminution of the visual field and central scotomata may persist. The nature of the disease is largely interstitial, limiting itself to the axial fibres of the nerve or those supplying the macular region, thus accounting for the presence of central blind spots.

Treatment.—The withdrawal of the drug causing this condition is the first indication. Stimulation by means of good food, fresh air, outdoor exercise, and drugs, such as strychnine and nux vomica, is indispensable. Dark glasses should be worn constantly, and the use of the eyes should be reduced to a minimum.

OPTIC ATROPHY

A diminution in the size with a corresponding diminution in the function of the optic nerve due to the wasting of its fibres and their replacement by connective tissue. It may occur as a primary affection, or it may be secondary to some other disease of the optic nerve or the eye.

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Causes.—Primary optic atrophy usually follows some disease of the spinal cord or brain, the most frequent being locomotor ataxia. It has been observed in this disease that the early appearance of the optic atrophy seems to postpone the appearance of the prominent symptoms, such as the lightning-like pains and the ataxic manifestations. Among the other diseases of the nervous system associated with optic atrophy may be mentioned disseminated sclerosis, paresis, and tumours of the brain. Less frequently it may be attributed to syphilis, malaria, diabetes, acromegaly, heredity, and certain toxæmic conditions. It may arise from impaired nutrition of the nerve, due to a great variety of causes, or it may take place without any apparent cause whatever. It seldom appears before middle life, and its course is somewhat prolonged.

Secondary atrophy of the optic nerve occurs as a termination of inflammation of the nerve or adjacent ocular structures, and is often called postneuritic optic atrophy. Its origin is demonstrated by the connective tissue that remains upon the disk, giving it a dense white or grayish colour, and causing more or less irregularity of outline and obscuration of the margins. This connective tissue also serves to hide the lamina cribrosa and the smaller papillary vessels. The veins of the retina enlarge and become irregular and tortuous, while the arteries become contracted and are outlined by white streaks at their borders, due to the thickening of the perivascular lymph-sheaths. This form of optic atrophy also follows retinitis pigmentosa, and in such cases the disk presents a grayish-red or yellow waxy appearance.

Causes.—This form of optic atrophy always follows disease or injury of the nerve. It is a common sequel to papillitis and retrobulbar neuritis, and is the terminal stage of neuroretinitis, retinitis pigmentosa, and other degenerations of the retina. Embolism of the central artery of the retina, thrombosis of the veins, and glaucoma are also followed by it. Injury to the optic nerve induces atrophic changes also, but these seldom become manifest until after a period of several weeks.

Symptoms.—In both forms of optic atrophy the symptoms of the ocular trouble are alike. A marked reduction in the visual acuity is one of the first manifestations. The visual field becomes contracted, first for colours and later for form. The light sense becomes diminished and scotomata make their appearance. Colour blindness soon follows, being at first for green and later for red

Megalopsia is the opposite condition, and is characterized by an overestimation of the size of objects.

Metamorphopsia is a visual defect in which the objects seen appear distorted.

Micropsia and megalopsia may be due to errors of refraction or disease of the visual centres. Metamorphopsia may arise from high degrees of ametropia, but is usually due to the presence of an inflammatory exudate in the retina or chorioid, as well as changes in fibres of the lens.

Muscæ volitantes are variously sized and shaped spots which float before the eye and are visible only to the patient. They diminish vision according to their size, and induce considerable annoyance by their presence.

COLOUR BLINDNESS

Daltonism; Achromatopsia; Dyschromatopsia.

In order to obtain a clear conception of this most interesting condition, it is necessary to consider the manner in which various colours are normally perceived. By the celebrated experiments of Sir Isaac Newton, white light was shown to be composed of seven primary colours—red, orange, yellow, blue, green, indigo, and violet—the waves or undulations of which differ greatly in their length and rate of vibration and also in their refrangibility. The red rays are the greatest in length, slowest in rate of vibration, and least refrangible, while the violet rays are the shortest, most rapid, and of greatest refrangibility. The colouration of objects depends upon the ability of their surfaces to absorb some of these colours while the remaining are reflected or transmitted. Total absorption gives rise to black, while total reflection induces white. An object that appears red has caused the yellow and blue rays to be absorbed. The withdrawal of certain colours from the white light always leaves behind a colour which is said to be complementary to the first. The mixture of complementary colours will reproduce light. Bearing in mind the complementary action, it is possible to further reduce white light into three primitive colours—red, green, and violet—as by their mixture in certain proportions a reproduction of white light is obtained.

These phenomena of colouration are present at all times, but for their perception by the eye that organ must be especially adapted. The exact manner in which this adaptability is accomplished is a matter of considerable discussion. The Young-Helmholtz theory assumes that the terminal fibrils of the retina are arranged in three distinct classes for the reception of these three primary colours just mentioned. These groups correspond to the three colours, and acting simultaneously induce the sensation of white. Red light entering the eye affects to the greatest extent the group of filaments known as the red sensitive elements, but also affects the others to a slight degree. In like manner green and violet are perceived by their corresponding sensitive elements. The absence or imperfect development of the retinal area set aside for one of these primary colours will cause this colour to be seen as if composed of the two remaining colours, thus giving rise to colour-blindness corresponding to the deficient colour-elements.

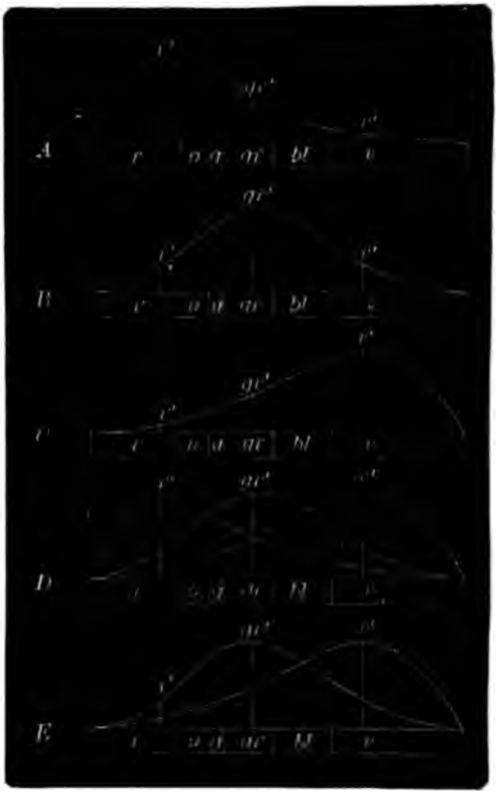


Fig. 122.—Representation of Colour Perception, according to the Theory of Young and Helmholtz.

The abscissa represents the spectrum, the colours of which are red, *r*, orange, *o*, yellow, *g*, green, *gr*, blue, *bl*, violet, *v* : the curves which rise above the abscissa show graphically the sensitiveness of the three sorts of fibres in the retina towards rays of different wave lengths. The ordinates, r^1, gr^1, and v^1, indicate the intensity of the stimulation of the fibres produced by red, green, and violet rays, respectively. *A* gives the curve representing the sensitiveness of the fibres for the perception of red; *B*, that of the fibres for the perception of green; *C*, that of the fibres for the perception of violet. In *D*, all three curves are represented at the same time. *E* shows the curves of sensitiveness of a red blind eye in which the fibres for the perception of red are assumed to be wanting.

The Hering theory is probably the best in that it explains certain rare forms of colour-blindness that would be impossible by the first assumption. It considers that the colour-perception elements are combined in three pairs—white-black, red-green, and blue-yellow. The perception of colour results from the assimilation or dissimilation of these visual substances. For instance, dissimilation of the first pair gives rise to the sensation of white, its assimilation induces black or darkness. These chemical changes cause the terminals of the nerve-fibres to transmit sensations to the visual areas in the brain where they are properly interpreted. As in the former theory, an absence or lack of development of one of these pairs induces corresponding colour-blindness.

The condition of colour-blindness may exist in individuals who are otherwise normal, and may be congenital or acquired.

The congenital form is present in about 4 per cent of males and 1 per cent of females, and usually attacks both eyes. The functions of the eyes are in other respects normal, and there is no structural alteration present to account for the defect in colour perception. The ætiology and pathology are unknown. The affection persists during life. It may be partial or complete—that is to say, one or more of the primary colours, red, green, or violet, may be unrecognised, or there may be loss of perception of all colours. Partial achromatopsia is the rule in congenital colour-blindness, while complete colour-blindness is an acquired form of the affection. No race is exempt from the congenital variety.

Acquired colour-blindness is most marked in atrophy of the optic nerve. It also occurs in the course of other diseases of the optic nerve and retina. Cerebral tumours, locomotor ataxia, paresis, traumatism, alcohol, tobacco, and syphilis may induce the acquired form of colour-blindness. It is usually complete, but may be partial, in which case it is most marked at a distance.

The practical significance of colour-blindness lies in the fact that the colours that are indistinguishable are those employed as signals upon railroads and in steamship service. The importance of the early recognition of this condition has until comparatively recent years been entirely ignored, but with the increase of commerce and travel the true relation of colour-blindness has been realized. As would be supposed, the congenital variety is least productive of danger, as the subject learns to regard things in their true colour frequently, although incapable of seeing them as they exist. In the acquired variety, on the other hand, the colour-blindness is insidious in its onset and progressive in its character. Arising as it does from causes that in addition dull the intellect, the patient is deprived of the aid which the "wits" would otherwise supply. Its occurrence at a later period of life when the mental faculties are undergoing rearrangement and deterioration is another great disadvantage. Based upon the knowledge of these facts, the larger companies concerned in transportation have arranged systems whereby the colour perception of their employees is taken every three or four years and recorded for future reference.

Tests for Colour-Blindness.—Holmgren's wools constitute the fundamental test. A number of variously coloured skeins of yarn are employed, six of which constitute the testing yarns, and the rest are used as confusion colours. In the practical application of this test the patient is handed a green skein and instructed to match it with a similar colour from among the bundle of yarns. The colour-blind individual will match it with the grays, yellows, pinks, and drabs without hesitation. The rose-coloured skein is then given to him with similar instructions, and colour-blindness for this colour will be demonstrated by his matching it with the light blues, violet, and purple. As a final test a bright red skein is employed, and if colour-blindness is present it will be confused with green, brown, and the darker colours. Dyschromatopsia may also be recognised by an inability to distinguish fruit from the leaves surrounding it, as in the case of cherries and strawberries.

Thomson's test consists of forty bundles of variously coloured yarns, all of which are numbered and so arranged that the odd numbers are the match colours and the even numbers are the confusion colours. These yarns may be placed in rotation upon a stick or may be thrown in a heap upon the table in front of the patient. The latter is probably the better method, particularly for those who undergo repeated examinations. The test colours are the green, the purple, and the red, and a selection of not less than ten tints is requisite. The numbers are recorded upon a chart, and the presence of colour-blindness is indicated by the even numbers in the report. The odd numbers from one to nineteen inclusive are the various shades of green, those from twenty-one to twenty-nine are purple, and those from thirty-one to thirty-nine are red. The principle is the same as in the preceding.

No less efficient but more practical are those tests in which variously sized and coloured lanterns and flags are employed, based upon the same principles of confusion of the primary colours.

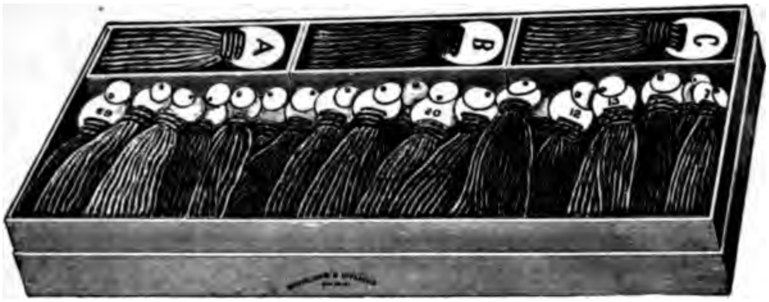


FIG. 123.—THOMPSON'S TEST FOR COLOUR-BLINDNESS.

Stilling's letters are also employed at times, and are ten in number. The test consists of plates of green or other colours marked off in forty squares, scattered through which are small squares of some opposite colour, arranged in the form of a letter or numeral. The colour employed for the background and for the figures differ in each plate, and the patient is required to trace the letter or numeral: an inability to do the same indicates colour-blindness.

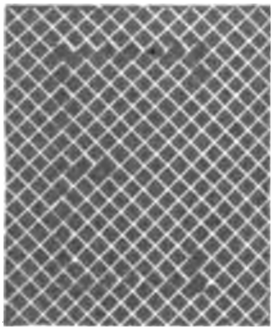


FIG. 124.—STILLING'S LETTERS.

The colour-sense may be detected by disks of red, yellow, green, and blue of various sizes. The distance at which these may be perceived indicates the acuity of the colour-sense, and this is directly proportionate to the distance and inversely as the size.

The treatment of colour-blindness is of no avail. In the acquired form it may be prevented by the avoidance of those conditions which are liable to induce it. In the congenital variety it is probable that it could be overcome to a great extent by the proper education of young children as regards colours in the kindergarten. The recognition of the finer shades and new tints is without doubt the result of a refinement in training. This has been neglected in the past, as has also the detection of colour-blindness in children, and many such individuals reach maturity before becoming cognizant of their true visual condition.

COLOUR-VISION

A condition in which colours are seen which do not exist. It may be of four kinds: erythropsia, or red vision; cyanopsia, or blue vision; xanthopsia, or yellow vision; or mixed.

Erythropsia is most frequent after cataract operation and exposure to extremely bright light.

Cyanopsia may also arise from cataract extraction, but seldom exists alone.

Xanthopsia is the most frequent form of colour-vision, and is present in icterus, yellow fever, acute yellow atrophy of the liver, and in posioning by phosphorus, santonin, amyl nitrate, and picric acid.

Mixed colour-vision is a symptom of poisoning by drugs that induce delirium in toxic doses, such as cannabis indica and salicylic acid. A variety of mixed colour-vision is encountered in glaucoma, in which the light seems to be surrounded by coloured halos or rainbows.

The treatment in all forms of visual disturbances consists largely in removing the underlying cause, as the condition itself is not amenable to medication.

CHAPTER XII

DISEASES OF THE CRYSTALLINE LENS

Aphakia.—The technical term for absence of the crystalline lens. The condition may be congenital or acquired. The congenital form is rather rare, while the acquired variety is more frequent, being present after cataract extraction and to some extent after luxation of the lens. It is manifested by entire loss of accommodation, deep anterior chamber, trembling iris, and considerable hyperopia.

The treatment consists in correcting the manifest hyperopic defect by convex lenses for distance, and adding an extra convex lens to take the place of accommodation for near work.

DISLOCATION

Luxation of the lens may be congenital or acquired.

Congenital Dislocation of the Lens (*Ectopia Lentis*).—Ectopia lentis, as the name implies, is a condition in which the crystalline lens is displaced from its normal position; this displacement as a rule is upward and outward, although occasionally it takes place in other directions. The dislocation is usually binocular, although cases of monocular displacement have been observed.

Causes.—The causes of congenital displacement have not been satisfactorily explained, although heredity has been shown to play a most important rôle in this condition. Tiffany mentions a case in which in one family 7 out of 9 children were affected; there was a positive history on the father's side. It is also said to be due to an absence of suspensory ligaments.

Treatment.—In partial displacement without marked disturbance of vision, operative interference is contra-indicated. Glasses should be prescribed and given a fair trial, although the results attending their use are not entirely satisfactory. An iridectomy may become necessary if there is great interference with vision. If the lens becomes cataractous subsequently it should be removed.

Acquired Dislocation of the Lens.—This variety of luxation is usually traumatic in origin. It may be partial or complete. Its situation varies according to the intensity and character of the violence that produced it; sometimes the lens is found posteriorly in the vitreous, and at others anteriorly in the anterior chamber.

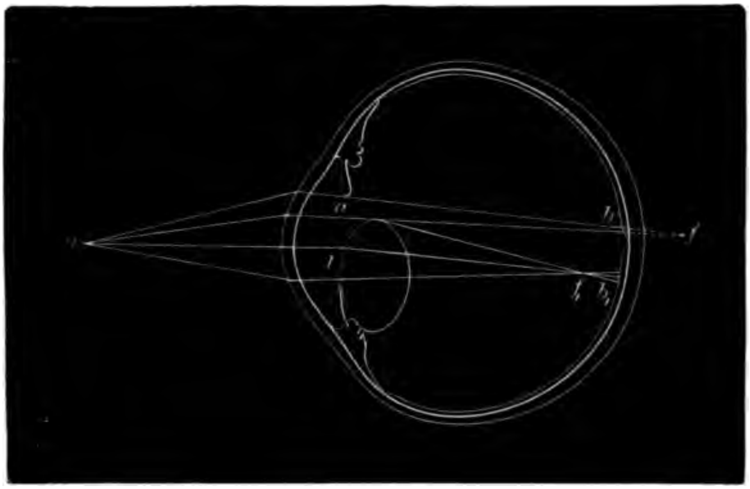


FIG. 125.—SUBLUXATION OF THE LENS. SCHEMATIC.

The lens has sunk so far downward that its upper edge is visible in the pupil. In consequence of the relaxation of the zonula it is much bulged out, and is in contact by its lower border with the ciliary processes; moreover, the lower half of the iris is pressed forward by it. Above, on the contrary, the anterior chamber, owing to recession of the iris, is abnormally deep. Of the beam of rays emitted by the luminous point *o*, a portion goes through the aphakic part, *a*, of the pupil; these rays, on account of the absence of the lens, are insufficiently refracted, so that they come to a focus behind the retina at *f*, and form upon the retina a diffusion circle, *b*. That portion of the beam passing through the section, *l*, of the pupil, which contains the lens, undergoes excessive refraction on account of the increased convexity of the lens, so that the rays intersect in front of the retina at f_1, and form upon the retina a diffusion circle, b_1. This latter gets to lie below the fovea centralis (and below the diffusion circle, *b*), because all rays passing through the lens undergo a deviation downward on account of the prismatic action of the latter. Thus two images of the point *o* are produced upon the retina (monocular diplopia).

In very rare cases attended by rupture of the sclera it may lie beneath the conjunctiva.

Causes.—Acquired luxation of the lens usually follows blows upon the eye by the fist, whip, or stick of wood, kicks, or some similar violence, but may occur in the course of diseases of the eye, such as malignant myopia and chorioiditis.

Symptoms.—Displacement of the lens into the anterior chamber may be recognised without any difficulty, as it resembles no other condition and can be detected by the unaided eye. When dislocated into the vitreous chamber it can only be seen by the aid of the ophthalmoscope. The lens may move back and forth through the pupil, depending upon the position of the head and body. The author has had two such cases of traumatic dislocation within three years; in both cases the lenses were calcified. Wherever the iris is unsupported by the lens, it will be found to be tremulous upon moving the eye, a most important diagnostic sign. There may be complete or partial loss of accommodation, depending upon the degree of dislocation of the lens. Monocular diplopia is frequent. Complete dislocation of the lens in the anterior chamber is apt to set up an irritation, and may, by occluding the angle of the anterior chamber, give rise to glaucomatous symptoms.

Treatment.—Removal of the lens is absolutely necessary when there is a complete dislocation into the anterior chamber of the eye, or when the condition gives rise to serious irritation. The method of procedure will be described under operations for cataract.

Since removal of the lens from the vitreous is a dangerous procedure, it is preferable to allow it to remain, and cases have been reported in which the lens has occupied this position for years, without giving any serious trouble. For such patients glasses should be prescribed.

If the lens is floating in the vitreous the following procedure may prove successful. The pupil of the injured eye is dilated and the patient made to lie on his face for several hours in the hope that the lens may gravitate through the pupil; if it does, the pupil is then contracted so that the lens is held in place in front of the eye, from which position it can readily be extracted through an incision in the middle of the cornea, pressure being exerted above and below. The author has succeeded in removing the lens in this way in two cases.

Coloboma of the crystalline lens is sometimes observed, but is extremely rare and is not amenable to treatment.

Lenticonus is an abnormal curvature of the posterior surface of the lens. It impairs vision somewhat, but is unaltered by treatment. Correcting lenses are often necessary.

CATARACT

Definition.—Any opacity of the crystalline lens or its capsule. Ordinarily the lens and its capsule are sufficiently transparent to be indistinguishable by the usual examination. Upon careful examination we observe that the lens when viewed obliquely is never perfectly transparent at any period of life. Even during childhood, when we would expect it to be perfectly transparent, we find by illuminating the dilated pupil very obliquely from the side, and looking at it from the opposite side, that it presents a very faint grayish reflex from the anterior portion or surface of the lens, the most striking portion of which has the form of a star, the branches corresponding to the lens sectors. This phenomenon is due to the fact that the light is refracted by the lens capsule or by the lens fibres themselves.

With increasing age the consistency of the lens is altered, so that cataracts occurring late in life are more hard than those in young persons. In persons past middle life we find that the reflex becomes more and more dense, so that in some elderly individuals the appearance of the pupil by ordinary illumination is similar to that of gray opacity of the lens, although the lens, as well as the patient's acuteness of sight, may be quite normal. In addition to this general loss of transparency, age is attended with a great liability to distinct localized opacities of the crystalline lens.

The lens may be altered in consistency, in size, shape, and transparency. According to Priestly Smith, a cataractous lens is smaller and harder than a normal lens of the same age.

Causes.—Age has a great influence upon the production of this condition, as it is most frequent after fifty years of life, but congenital cataract is also encountered. The manner in which it is brought about, however, is not clear, but it is probably due to some disturbance of nutrition. Heredity is said to be a factor. Diseases such as diabetes, nephritis, gout, rheumatic diathesis, arterial disease, syphilis, etc., are also assigned as causes in certain cases. The artificial production of cataract in frogs by the administration of sugar has been reported by S. Weir Mitchell. Occupation seems to exert some influence in its production, as glass-blowers and those exposed to high degrees of light and heat are affected with uncommon frequency. Traumatism, directly or indirectly applied, is a cause in some cases. Toxic conditions, such as ergotism, have been followed by it. Ocular affections, such as iritis, irido-cyclitis, ulcerative keratitis, uveitis, malignant myopia, chorioiditis, glaucoma, retinitis, and detachment of the retina are particularly prone to induce cataract. Uncorrected ametropia is also a predisposing factor.

Symptoms.—Diminution of vision is perhaps the most prominent symptom. It varies according to the situation and character of the opacity. A peripheral cataract may be undetected for a long period, as it occasions very little disturbance of vision, while central opacities produce a marked diminution in visual acuity. Haziness and spots before the eyes are complained of by the patient, together with double vision and distortion of images. In the early stages, particularly in senile cataract, the swelling of the lens produces myopia and the patient is able for a while to discard reading-glasses. This condition, however, is not permanent, and constitutes "second sight" of the laity.

Inflammatory symptoms may be present, but are not dependent upon the lens condition. The anterior chamber may be normal in depth, or it may be shallow or deep, according as the lens is swollen or contracted. The pupil may be normal, but is usually dilated on account of the obstruction the opaque lens offers to the passage of light to the eye-ground, thereby interfering with the pupillary reflex. The colour of the pupillary area varies from a grayish hue to black, depending upon the maturity of the cataract, but at no time is the pupil filled by the normal bright-red reflex. Examination by means of the ophthalmoscope shows a black spot on a red ground in the early stages, but in the late stages the red ground is entirely effaced.

Varieties.—Cataract may be congenital or acquired. Congenital cataract may be due to faulty development or prenatal ocular inflammation, and includes anterior and posterior polar, lamellar, and occasionally complete cataract. All the other varieties are acquired by senile changes, injury, or adjacent inflammatory conditions.

According to the character of the cataract it may be considered as primary or secondary. Primary opacities arise independent of any obvious cause. Secondary cataracts are also called complicated, and follow ocular diseases and operations.

The consistency of an opaque lens also affords another classification, so that cataracts may be known as soft and hard. Soft cataracts are white in colour and without any hard nucleus being encountered in persons under thirty years of age. Hard cataracts are distinguished by their hard nuclei and yellowish, sometimes darker tint, and occur later in life.

A division according to the extent of the opacity may be made, so that a cataract may be considered as complete or partial. Complete opacities involve the entire lens; partial cataracts are limited to one portion of that structure.

Cataracts may be capsular, lenticular, or capsulo-lenticular, according to the situation of the opacity.

The progress of the opacities serves to classify them as stationary and progressive. Stationary cataracts are subdivided into anterior polar, posterior polar, lamellar, and certain other congenital forms. Progressive cataracts include senile (cortical and nuclear), traumatic, and some congenital varieties. This form is further subdivided, according to their stage of ripeness, as immature, mature, and hypermature (Morgagnian).

Diagnosis.—Although failing vision is always accompanied by a more or less grayish condition of the lens, cataract is not necessarily present, and it is of greatest importance to recognise the true condition on account of the great differences in treatment. Oblique illumination serves to display opacities, striæ, and the maturity of the cataract. The condition of the anterior chamber can be readily observed, and the presence of swelling or contraction of the lens is easily determined thereby. The candle-test is also of value in this connection. Normally, a lighted candle moved before the eyes gives rise to three images: one on the anterior surface of the cornea, a second on the anterior surface of the lens, and a third inverted image on the posterior surface of the lens. In cataract the inverted image is no longer seen, and the image on the anterior surface of the lens also disappears if the capsule is involved. In complete cataract the corneal image alone is visible.

The candle-flame test was discovered by Sanson in 1836, and is one of the best means of distinguishing cataract from other conditions associated with blindness. It is an adaptation of Purkinje's test for accommodation. For its satisfactory performance the patient should be seated in a darkened room and the pupil dilated.

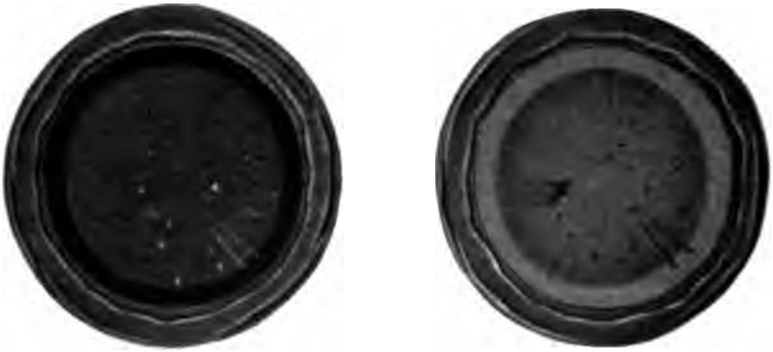
Treatment.—This consists in removal of the opaque lens. The manner in which this is performed varies according to the character of the cataract, and will be discussed under the descriptions of the different types of cataract.

SENILE CATARACT

SYNONYMS: *Simple cataract; Gray cataract.*

The term "senile cataract," sometimes known as "hard cataract," is justifiable when the disease occurs in persons of advanced age—over forty-five years. It is met with most frequently between the fiftieth and seventieth years. The term "hard cataract" is applicable on account of the increasing rigidity and size of the nucleus, which accompanies age.

Symptoms.—Senile cataract is the most common as well as the most important form of cataract with which the ophthalmic surgeon has to deal. The patient complains of but one symptom, namely, a slowly increasing dimness of vision. This form of cataract develops very gradually; in fact its development is occasionally so slow that sight may be lost in one eye before any impairment of vision is complained of by the patient. In a few cases the condition develops very quickly to a point where there is partial loss of vision, and then remains stationary for a time, or progresses very slowly. The opacity generally begins at the periphery of the lens, when it is known as *cortical cataract,* though it not infrequently originates at the centre of the lens, in which position



a FIG. 126.—PERINUCLEAR CATARACT. *b*

a, by oblique illumination; *b*, by ophthalmoscope.

it is known as *central* or *nuclear* cataract; or, it may develop in both these positions simultaneously.

It is rarely observed in individuals under fifty years of age, and the time required to reach maturity, or involve the whole body of the lens, varies greatly after its inception, the process sometimes extending over a period of years—the average time being about three years. In those cases where the opacity is not symmetrically distributed throughout the lens, the acuity of vision may vary, being perhaps better in a feeble light in one case, and in another better in a strong light. The grayish or dulled translucency of the capsule observed in old people, and a purely physiologic phenomenon, is sometimes very difficult to differentiate from incipient cataract. By oblique or focal illumination these two conditions may look alike, and a correct diagnosis cannot be made by this means, but on using transmitted light at a distance of several inches the difference can easily be noted.

In most cases the impairment of vision is not so great as to interfere with the counting of fingers held a few inches from the eye, but in some instances movement of the hand cannot be detected. In nearly all cases of senile cataract light perception is retained.

Impairment of vision in the first stages of cataract may be due to refractive changes, rather than to the lessening of the translucency of the lens. There may, for example, be an increased refraction at the nucleus, causing myopia when the pupil is contracted, or negative aberration when the pupil is dilated. In other eyes irregular astigmatism is produced by the refractive change, giving rise to sectors of light and shadow very closely resembling cortical opacities of the lens.

Progressive cataracts usually pass through the following stages:

The *incipient stage*, in which there is more or less opacity, although some portions of the pupil still remain clear enough to give imperfect though useful vision. The beginning of the opacity is marked by streaks that extend from the periphery to the centre of the lens and resemble the spokes of a wheel. By oblique illumination these streaks present a grayish appearance, but when viewed by means of the ophthalmoscope they appear black. The portions of the lens between these striæ are transparent. Not infrequently the opacities begin as dots or clouds, coalescing as maturity is reached. These may form at the cortex or in the nucleus and gradually extend over the entire lens—the *stage of swelling* or intumescence, in which the lens becomes swollen by imbibition of fluid. The iris, in consequence of this swelling, is pushed forward, making the anterior chamber of the eye more or less shallow. The opacity has become more marked than in the first stage, though it is still incomplete. The stellate appearance of the lens is more distinct, and the cataract appears bluish-white in colour. The superficial portion of the lens is still transparent, so that upon oblique illumination the iris casts a shadow upon the lens. Myopia makes its appearance in this stage, so that the patient is able to dispense with reading-glasses for a time.

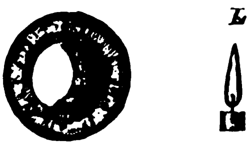


Fig. 127.

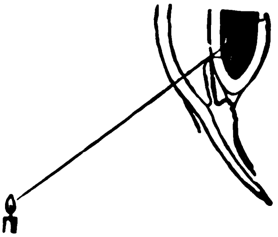


Fig. 128.

FIG. 127.—SHADOW OF THE IRIS SEEN FROM IN FRONT.

The crescentic shadow appears at that side of the pupillary margin that is turned toward the source of light, *L*.

FIG. 128.—SHADOW OF THE IRIS UPON THE LENS IN SCHEMATIC CROSS SECTION.

The inner layers of the lens are supposed to be opaque, the peripheral ones transparent. The source of light, *L*, throws upon the surface of the opacity a shadow from the iris, whose central border is at *b*. An observer, looking from a point straight in front of the eye, sees a portion of this shadow, of the width *a b*, running alongside of the pupillary margin of the iris.

The *stage of maturity* is that in which the lens is completely translucent, and, unlike the second stage, is not swollen, but has returned to its original size. The anterior chamber is of normal depth. It is during this stage that the operation of extraction is productive of best results.

The following test is employed to determine whether or not a cataract is "ripe." The eye is obliquely illuminated: if the iris throws no shadow on the lens substance behind it, or if no shining sectors are seen, and there is no transmission of a reddish glare, the cataract is mature. If an area of blackness is clearly visible behind the iris, on the inner or outer side, it indicates that the lens is not mature at its periphery.

Another indication of the maturity of a cataract is found in the peculiar mother-of-pearl lustre of the surface of the lens under oblique illumination. When the red fundus reflex cannot be seen with the ophthalmoscope through a dilated pupil, we have further evidence of its maturity. If the patient cannot count fingers at arm's length, when seated with his back to a window, we may assume that the cataract is mature.

The reason operation is of most benefit in this stage is on account of the ease with which the opaque lens can be separated from its capsule, thus lessening the liability to after-cataract from remnants of the cortex left behind.

The *last stage* is that of hypermaturity or overripeness. In this stage we find the lens shrunken, hardened, occasionally calcareous, and the lens capsule thickened and tough, and often thrown into ridges or folds.

In hypermature or "overripe" cataracts the cortical portions undergo fatty degeneration and liquefaction. The nucleus still preserves its amber cast, and may be displaced to the lower part of the capsule. This form of cataract, which is usually found in patients over sixty-five years of age, and in whom the cataract has existed for from five to ten years, is known as a *Morgagnian cataract.*

Treatment.—If a positive diagnosis of cataract has been made, the question as to whether or not we should frankly tell the patient that he has a cataract, or simply make a diagnosis of "incipient lenticular opacity," depends upon the judgment of the physician and the character of the patient: each case must be decided for itself. It is justifiable to partially conceal the truth from the patient by making the latter diagnosis if only one eye is affected, the other remaining normal, since it will be a matter of great comfort to the suffering individual. (The friends of the patient should, however, be informed as to the true condition of affairs.) To wait an indefinite period of time for the ripening of a cataract in each eye is a source of extreme mental distress.

Tinted glasses, which increase the diameter of the pupil, will occasionally afford a measure of relief to the patient. Atropine should not be used for this purpose, except in rare cases; if it is, and in a few cases it is justifiable, the patient should be kept under surveillance by the ophthalmic surgeon. Both convex and concave spherical lenses may be tried.

It must be borne in mind that we must ascertain whether the retina and optic nerve are in normal condition before we advise an operation for cataract. The patient's light-projection should be tested, as well as the reaction of the pupils to light.

A satisfactory test for light-projection may be made with a lighted candle in a dark room. The patient is asked to keep his eye fixed and in a certain direction, and the candle is then moved about in different quadrants of the visual field. If the patient locates the source of light promptly, we may assume that the retina is in good condition, and that, if no inflammatory reaction follows the operation, a favourable result may be anticipated.

To ascertain whether the irides respond promptly to light, both eyes are covered by the hands, thus placing them, as it were, in a darkened chamber. The pupils should, of course, dilate under this condition. One hand is then suddenly removed from the cataractous eye: if the retina appreciates light, the pupil suddenly contracts.

Methods designed to hasten ripening of the cataract are not infrequently employed. In some cases this result has been achieved by massage of the lens. Indirect massage is performed by tapping the anterior chamber of the eye, drawing off the aqueous substance so that the lens falls against the cornea, and then stroking the cornea with a corneal spatula within the area of the pupil, which has been previously dilated with atropine. Or, an iridectomy may be performed and the cornea, over the area of the pupil and the coloboma of the iris, similarly massaged. Direct massage is performed either with or without an iridectomy, by introducing a spatula into the anterior chamber of the eye and then stroking the anterior lens capsule. Puncture of the lens may be followed by swelling of the lens and glaucomatous symptoms, and iritis may supervene.

Operations should not be performed on both eyes at the same time, even though both cataracts are mature. Some surgeons will not remove a ripe cataract if the vision of the other eye is perfect, or nearly perfect, because the difference in refraction renders binocular vision impossible, and the patient is not so well satisfied with his sight after the operation as before. In the author's experience, however, matters have been somewhat different: although binocular vision may not have been obtained, yet the enlargement of the visual field amply compensates for this loss.

The special difficulties that the ophthalmic surgeon experiences in removing a cataract before maturity are that parts of the cortex, clear at the time of operation, will remain adherent to the capsule of the lens, and later undergo the process of opacification, thus again impairing vision until absorbed or until removed by an operation for capsular cataract.

Some operators, however, operate on immature cataracts, washing out the tenacious material with a syringe. This is advisable in patients over seventy years of age, since the lens is hard enough to be extracted without leaving any cortical mass behind. If a choice between operating on an immature cataract or artificially hastening maturity becomes necessary, the former would seem preferable.

It should always be known with certainty that a cataract is ripe before an operation is performed. If an unripe cataract were removed, a portion of the lens would almost inevitably be left intact, and in the course of time this would probably become opaque and necessitate a second operation.

The best operation for cataracts is extraction of the opaque lens preceded by an iridectomy. The details of the entire operation will be described in another portion of this chapter.

Prognosis.—There is a great want of uniformity between the percentages of cures given by the different operators. It may be said, generally, that if the patient is in good condition, and the tissues are as elastic as is consistent with the age of the patient and the light perception is clear and decisive, a good result is to be expected.

Spontaneous disappearance of lenticular opacities does occur, but is extremely rare. For literature upon this subject, see paper by W. L. Pyle, Journal of the American Medical Association, October 18, 1902.

Black Cataract.—Opacification of the crystalline lens that assumes a brown-black colour is a comparatively rare condition. Its density is greater than in other forms of cataract, and the cause of this peculiar colouration has given rise to considerable conjecture. Müller attribued it to malanosis; Langenbeck considered it as due to the presence of manganese, while Lawrence and Guthrie supposed it to be produced by the oxide of iron in the lens. Some of the more recent authorities believe it to be derived from the blood pigment.

The existence of black cataract has been much disputed until within comparatively recent years. Dupuytren had never seen one, and denied it as a possibility. Desmarres, Pellier, Wenzel (senior), Graefe (senior), and Lusardi, however, described accurately cases under their own observation that excluded any doubt as to its existence. Among ophthalmic surgeons of the present day it is subjected to but passing mention on account of its rare occurrence. In my own experience I have encountered and extracted five "black cataracts." In one of these cases there was a dark nucleus embedded in the semitranslucent part of the lens, while beyond was a yellow band. The diagnosis of black cataract can only be made by oblique illumination.

Dr. Swan M. Burnett has given a capital description of this form of cataract, which may be read with interest.

RECURRENT CAPSULAR CATARACT

Synonyms: *Secondary or membranous cataract; Opaque capsule; Secondary pupillary membrane; After-cataract.*

Definition.—A condition characterized by an opacity of the lens capsule, either posterior or anterior, which exists or develops after removal of the crystalline lens.

In performing a cataract operation either a part of or the whole lens capsule is allowed to remain in the eye. A number of operations have been devised for the purpose of removing the entire capsule as well, but the difficulty and the risk attending these operations bear no proportion to the advantages that are secured.

The recurrent capsular cataract is produced as follows:

After an operation for the removal of cataract has been performed, the transparency of the lens capsule is altered, and the adherent cortex at first swells and becomes more or less opaque. In a short time the opacity of the capsule disappears and the cortex likewise becomes absorbed, the vision improving greatly in a week or ten days after the removal of the cataract. Later the capsule undergoes a process of thickening, due to proliferation of the epithelial cells on its under surface, so that the vision obtained as a result of the operation again diminishes to a greater or less extent. Sometimes the capsule after the operation becomes shrivelled or puckered, thus producing a disturbance of vision nearly as troublesome as an opacity. In other cases, as after the extraction of an immature cataract, a portion of cortex is quite frequently left behind even by the most careful and experienced surgeon, and this gives rise to an opacity that may entirely occlude the pupil. Absorption takes place, but often requires months for its completion. A second needling operation or a capsulotomy is a more certain way of removing it.

The diagnosis is easily made by oblique illumination or by means of the ophthalmoscope. The pupillary area is partially or completely filled with an opaque material resembling the original cataract, but which is less extensive.

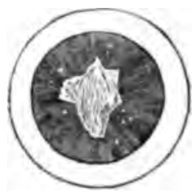


Fig. 129.—Capsular Cataract in a Case of Hypermature Cataract.

The centre of the dilated pupil is occupied by an irregular, brilliantly white capsular thickening, upon which can be recognised the fine wrinklings of the capsule. In the vicinity of the large capsular opacity are found thickenings of the capsule, which have just developed and which form white dots contrasting strongly with the subjacent brownish and radially striate, opaque lens.

The second operation should be deferred until after all signs of irritation from the previous one have disappeared. This is usually from about six or seven weeks to three months. After-cataract may be removed by needling or capsulotomy.

ZONULAR OR LAMELLAR CATARACT

This form of cataract is usually congenital, though not infrequently it develops in early infancy. It is generally bilateral, though rare cases have been observed in which one eye only was affected. Since vision is not materially impaired by it, it often escapes detection until a much later period in life. On dilating the pupil with atropine, an opacity of the lens is observed. In cases of congenital origin this opacity is thought to be produced by a temporary interruption of nutrition during the formation of the lens.

In those cases in which the condition develops during infancy a history of convulsions can be obtained usually, and the various landmarks of rhachitis may be detected upon careful examination. Heredity is an important factor in the ætiology of this form of cataract. Syphilis is sometimes the underlying cause.

The opacity is situated between the nucleus and periphery, the remaining portion of the lens being normal.

On examining the eye by oblique illumination it appears of uniformly light gray colour, sharply defined, and surrounded by a more or less broad margin of transparent cortical substance.

If the opacity is not dense, vision may be relatively good, so that large print can be read with ease. Sight may generally be improved by dilating the pupil with a weak solution of atropine, which permits the rays from the object to pass through the clear marginal portion of the lens.

Individuals suffering from this variety of cataract are quite often supposed to be myopic, as they hold small objects very close to the eye in order to gain larger retinal impressions. In point of fact, the majority of these patients are hyperopic, since the interruption of development of the lens is frequently accompanied by interruption in the development of the eyeball, and a small eyeball is hyperopic. Nystagmus is a common symptom.

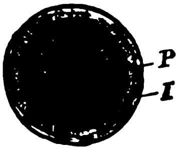


FIG. 130.—LAMELLAR CATARACT SEEN BY REFLECTED LIGHT. Magnified 3 × 2.

The iris, *I*, has retracted under atropine. The opacity forming the lamellar cataract is denser at the margin than at the centre. The riders are depicted in the upper half, but are left out below to show how a lamellar cataract looks without them. Between the margin of the opacity and the margin of the pupil, *P*, is a black interspace corresponding to the transparent periphery of the lens.

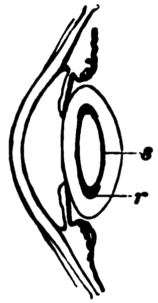


FIG. 131.—LAMELLAR CATARACT IN CROSS SECTION. SCHEMATIC. Magnified 2 × 1.

The layers, *s*, placed between nucleus and cortex, are opaque, but the adjacent layer is so only in the equatorial region, *r*, so that riders are formed.

Zonular cataract is usually stationary. If vision is not greatly improved by dilating the pupil, some improvement is to be hoped for by performing an iridectomy. Discission should be performed at once unless there is evidence of calcareous deposit in the lens, in which case an iridectomy, or the complete removal of the lens, is necessary.

DIABETIC CATARACT

This form of cataract, which is associated with diabetes (6 per cent of diabetic patients have cataract) is usually of the soft variety and matures slowly; the author has observed cases, however, in which maturity was reached in from three to six months. The blood in diabetic patients is below normal, the percentage of solids being greater than under normal conditions. This gives rise to an exosmosis of the watery constituents of the lens, a loss of transparency in its fibres, and a deposition of calcareous and other salts.

The diabetic lens is uniformly opaque. The cataractous condition usually does not appear until a later stage of diabetes, when the patient is greatly enfeebled and much broken down in health.

Diabetic cataract is most frequently met with about middle age, and is usually bilateral. The perception of light and the condition of the visual field should always be very carefully tested in this variety of cataract, as affections of the retina and optic nerve not infrequently occur in the course of diabetes, and if such diseases coexist with the cataract, an operation may be of no avail.

The method of extraction is optional with the surgeon; the author performs the simple operation—i. e., without iridectomy. My method consists in making a large flap incision in the cornea, and I have found by adopting this method that the eye recovers from the operation almost as well as in patients who are not suffering with a constitutional disease.

PYRAMIDAL CATARACT; ANTERIOR POLAR OR CAPSULAR CATARACT

This form of cataract may be of congenital origin, though these cases are rare. It is usually acquired in childhood, in the following manner: In perforating ulcer of the cornea (such, for example, as is sometimes met with in ophthalmia neonatorum), the anterior chamber of the eye is emptied, the lens is pushed forward and comes in immediate contact with the inflamed cornea, the perforation becoming closed by lymph deposition. When the lens resumes its normal position, as a result of the refilling of the anterior chamber, it carries back some of this exudative material, which adheres to the lens as a cone-shaped body, about the size of a millet-seed. The author has also observed this condition following cases of ophthalmia neonatorum, where there has been great œdema of the lids, and consequently a great deal of pressure on the cornea irritating the anterior capsule of the lens or possibly Descemet's membrane, and giving rise to this white deposit without perforation of the cornea.

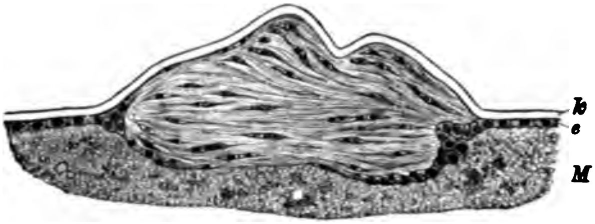


FIG. 132.—ANTERIOR CAPSULAR CATARACT. Magnified 40 × 1.

The capsular cataract forms a projection upon the anterior surface of the lens, covered by the capsule, *k*, which is unchanged and simply thrown into folds. The capsular epithelium, *e*, loses its regularity at the border of the cataract, its cells being increased in number and separated by the cataract from the capsule, so as to form for a short distance the posterior boundary of the cataract. The cataract consists of a fibrous tissue, with cells lying in the spindle-shaped gaps between the fibres. Succeeding the cataract posteriorly is liquor Morgagni, *M*, which is coagulated into a pulverulent mass, separating the capsule from the cataractous layers of the lenticular cortex (which are not represented in the drawing).

The condition is scarcely ever serious enough to require an operation, unless, of course, the opacity is large enough to fill the pupillary space, in which case an iridectomy would be suggested.

POSTERIOR POLAR CATARACT

This form of cataract may either be congenital or secondary to chorioiditis or retinitis; in the former case it may be due to vestigial remains of the hyaloid artery at its lenticular attachment.

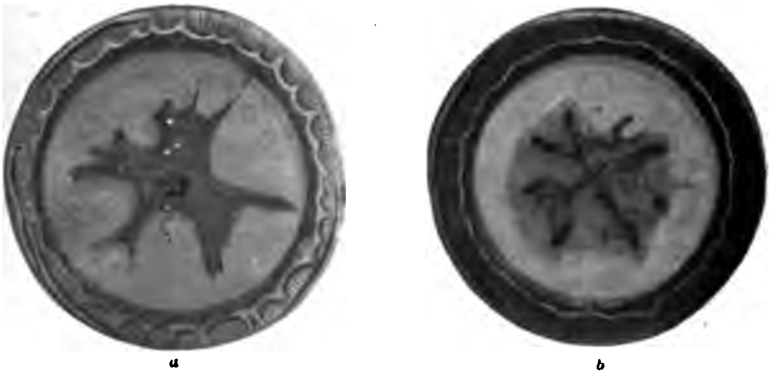


FIG. 133.—POSTERIOR POLAR CATARACT.
a, with diffuse chorioretinitis; *b*, with retinitis pigmentosa.

Posterior polar cataract can only be discovered by the careful use of the ophthalmoscope, with which it appears as a small black spot against the red fundus reflex.

A larger area of opacity, often assuming the shape of a radiating figure, constitutes another variety; still other forms resemble the rings of Saturn. In the event of coexistence of retinitis or chorioiditis the prognosis is of course materially affected.

It frequently remains stationary for a long period and then progresses toward complete cataract.

Treatment is rarely called for in this variety of cataract. If, however, an operation becomes necessary, an artificial pupil may give good results; and if this measure fails, discission will probably be indicated.

DISSEMINATED DOT CATARACT

C. Wray * describes a form of cataract "characterized by the presence in the lens structure of numerous very thin, small, whitish or bluish punctiform deposits, nearly always less than 0.5 millimetre in diameter." These dots are most numerous towards the equator, and are situated so far towards the periphery of the lens that they are apt to be overlooked unless a very careful examination is made under focal illumination.

In this form of cataract no active interference is necessary.

TRAUMATIC CATARACT

Traumatic cataract is produced by an injury to the lens; the most common cause being the entrance of a foreign body through the cornea which ruptures the lens, although cases have been reported in which the lens was dislocated or even ruptured without any wound of the coats of the eyeball.

It is only in very rare cases that a foreign body enters the lens substance without producing cataract. The mere pricking of the lens with the point of a knife, as may accidentally occur in performing an iridectomy or paracentesis, is sufficient to produce cataract, and there is no question that the condition has frequently been produced in this way.

If the capsule is perforated by the entrance of a foreign body,

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* Trans. of the Ophthalmological Soc. of the United Kingdom, vol. xii, 1892, p. 109.

the aqueous is admitted to the substance of the lens, which may rapidly become opaque. Should, however, the perforation be rather small and superficial, the attendant danger may be very slight, since there is a possibility that the lips or edges of the minute wound will unite, in which case if an opacity does form it will not be extensive. On the other hand, if the wound be larger and deeper, a greater amount of aqueous is admitted into the lens, which consequently becomes swollen, and, by exerting pressure on the iris and ciliary body, may set up an inflammation involving these bodies. This inflammation may be either serous or purulent, depending upon the extent and nature of the irritation.

The lens usually becomes more rapidly opaque in younger than in elderly individuals. Cases have been observed in which the entire lens became completely cataractous in the course of a few days after the injury.

In cases of injury to the lens, the intra-ocular tension, the condition of the sight, and of the visual field should be frequently examined, so that if symptoms of glaucomatous or other complications make their appearance they may at once be detected and the necessary treatment instituted. There is a remote possibility of sympathetic ophthalmitis, and this should always be borne in mind.

Traumatic cataract is occasionally the result of a simple contusion of the eye, without any laceration of its outer or external coats. A blow upon the eye, or over the head, from a fist or some blunt body (a piece of wood, whip, brick, etc.), may give rise to this form of cataract.

This is evidently due to a laceration of the zonule of Zinn or the suspensory ligament, which prevents the normal nourishment of the lens. The laceration of the lens capsule depends particularly upon the character of the blow received, and especially upon its force.

Treatment.—The eye should be placed at absolute rest by the instillation of atropine. The presence of a foreign body will require treatment suggested under foreign bodies in the eyeball. Extraction of the foreign body is always indicated. The occurrence of iritis will necessitate extraction of the lens as soon as possible. Purulent inflammation may follow, leading to destruction of the eyeball and requiring enucleation.

CATARACT OPERATIONS

All patients presenting themselves for a cataract operation should be carefully interrogated as to their general habits and family history, and a careful urinalysis should be made.

The patient's diet should be largely vegetable, meat being excluded, and this regimen should be insisted upon for several weeks preceding the operation. One week before the operation the patient should be placed on mixed treatment, mercury and potassium or sodium iodide, and particular attention paid to bathing both eyes with a boric-acid solution containing sulphocarbolate of zinc.

The nasal cavities should be subjected to a most careful examination, and if any catarrhal affections are detected, it is of paramount importance that they receive proper attention before the operation is performed.

The day before the operation the patient is given a warm bath, saline purgatives, kept in bed, and his face washed with castile soap and water. Two hours before the operation the skin around the eye to be operated on is carefully washed with ether; following this by placing eye-pads saturated with a 1-to-2,000 solution of corrosive sublimate over both eyes. These measures are frequently repeated in all cases where the cornea is incised, and just before the incision is made the additional precaution of dropping 1 or 2 drops of a 1-to-2,000 bichloride-of-mercury solution on the cornea is taken. The preliminary washing with ether may be omitted in many cases. The instruments and bandages are, of course, always carefully sterilized. The eye to be operated upon should be thoroughly anæsthetized by means of a 5-per-cent solution of cocaine instilled into the eye.

The author prescribes 1 to 2 grains of mercury with chalk three times daily for a week or ten days before an operation. This preliminary treatment is of great value in lessening the risk of secondary complications.

In childhood, or in adults up to thirty years of age, the needle operation is performed. After this age a corneal incision should be made. Extreme age does not seem to contra-indicate an operation. The author has successfully removed a cataract from a patient ninety years old; Professor Mauthner operated successfully on a patient one hundred and one years old.

EXTRACTION THROUGH A CORNEAL INCISION

The operation most commonly in use for cataract at the present time is extraction through a corneal incision, with or without an iridectomy. The eye is anæsthetized by making several instillations of a 5-per-cent cocaine solution at short intervals before the operation, say five minutes. General anæsthesia should never be induced unless absolutely indicated; and if it must be brought about, chloroform is preferable to ether. If the right eye is being operated on, the surgeon stands behind the patient's head; if it is the left eye, and the surgeon is not ambidextrous, he must stand in front and to the left of the patient. If ambidextrous, the surgeon stands in front of the patient and on his left side.

The pupil should always be dilated one hour before the operation is performed. The author prefers atropine (2 drops of 1 grain to a 3-dram solution) for this purpose. An eye speculum is inserted and the conjunctiva is seized with the fixation forceps at the corneoscleral margin opposite the point of incision, and below the horizontal plane of the cornea. By means of a Graefe knife a puncture is made 1 millimetre beyond the cornea, and 2 or 3 millimetres below a line drawn across the eye at the upper corneal margin; the incision in this operation is not quite equal to one-half the circumference of the cornea. The counter-puncture is made at a point on the opposite side of the cornea which exactly corresponds with the original puncture. The knife is now worked upward through the cornea by a scimiter sweep, the section terminating close to the iris at the upper corneal margin. At this point a small flap in the conjunctiva is usually made by a second sweep (Snellen). Sometimes a slow to-and-fro motion is employed in making the incision.

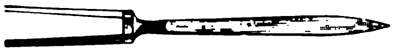

FIG. 134.—CRITCHETT'S MODIFIED GRAEFE KNIFE.

The knife should be slowly withdrawn to prevent any undue escape of the aqueous with consequent prolapse of the iris.

If an iridectomy is to be included in the operation it is made at this stage. The closed iris forceps are introduced and passed through the anterior chamber. The blades of the forceps are now opened and a portion of the iris grasped and slowly drawn through the centre of the wound, and towards the operator's face. The iris between the cornea and the forceps is now severed by scissors (De Wecker) with one cut. This gives the key-hole iridectomy so much desired.

Whether an iridectomy should be performed or not is a question that has not yet been finally decided. The advantages of this procedure lie in the fact that the iris is not so likely to be injured during the delivery of the lens, and there is also less danger of its becoming incarcerated in the lips of the wound. On the other hand, an iridectomy will leave a disfigurement and possibly occasion the patient some slight visual trouble. Some operators, indeed, insist that an iridectomy should be performed some time in advance of the operation for removal of the cataract. The author does not think this procedure is justifiable, and he generally performs an iridectomy during the cataract operation.

In rupturing the capsule of the lens, Jaeger's cystotome is employed, it being less dangerous than the ordinary straight cystotome in common use. The author follows the method adopted by Jaeger, making a rectangular opening in the anterior capsule. Pressure on the cystotome must of course be avoided, otherwise the lens may be dislocated.

The patient now directs his eye downward, and pressure is exerted towards the centre of the pupil on the lower part of the cornea. This causes the wound to gape, and slowly forces the lens out. A spatula may be applied over the upper edge of the wound and the lens delivered. Great care must be taken to see that all cortical matter is removed from the anterior chamber and that the iris does not become incarcerated in the lips of the wound.

A spatula is now introduced and the iris carefully replaced. If no iridectomy has been performed, and the iris cannot be properly replaced, a small portion must be excised.

The operation is not complete until all particles of cortical matter have been expressed by gentle manipulation and pressure by the finger through the lower lid or by the spatula, and when this has been accomplished the pupil will be entirely black.

The eye is now thoroughly cleansed with sterile boric-acid solution and the pupil contracted by one drop of eserine. In the combined operation the instillation of eserine should not be made.

The after-dressing in cataract operations is a very important factor in its successful termination. Every ophthalmic surgeon has his own peculiar way of applying a dressing to an eyeball. The method adopted by the author consists in dropping a few drops of 1 to 2,000 mercury bichloride solution into the eye immediately after the operation. The eyelids are then closed and one or two drams of sterilized vaseline applied. Eye-pads and a perforated metal shield, held in place by adhesive plaster, serve to protect the eye. The fact that the author has employed this method of dressing for fifteen years, combined with the large number of cases dis-

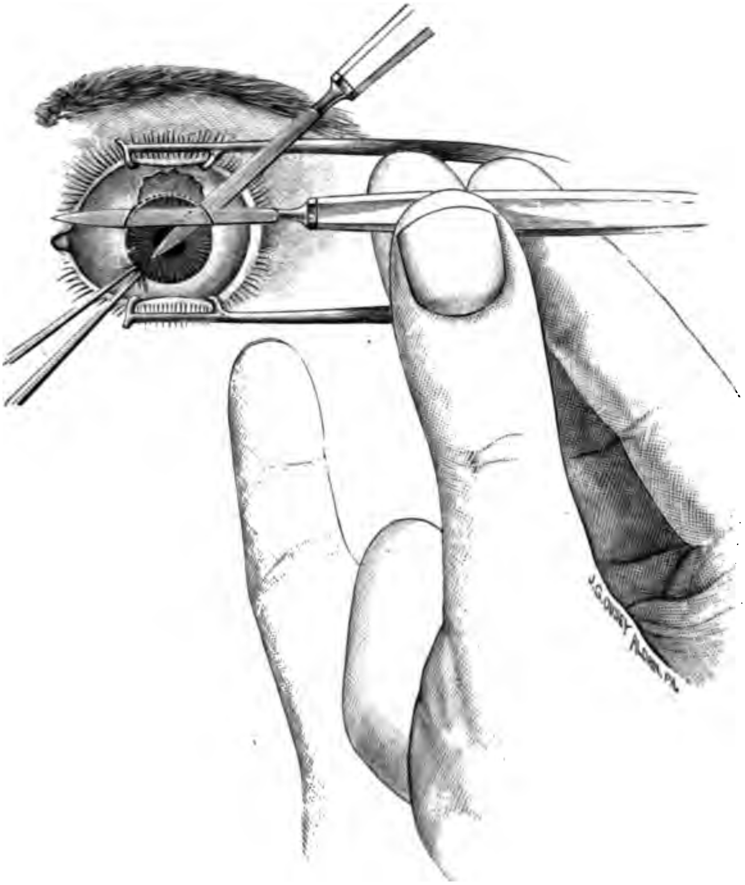

Fig. 135.—Cataract Operation. Showing position of fingers.

charged from the hospital in nine or ten days after the operation, speaks well for its efficiency.

Besides minor modifications of the corneal incision operation, such as making the incision downward, we have Pagenstecker's operation, in which the lens is removed in its unbroken capsule. In this operation, which perhaps ranks next in importance to simple extraction, the incision is made in the sclera 1 millimetre from the cornea, and, after an iridectomy, the lens is removed in its capsule by a scoop.

Surgical operations for the cure of cataract have been performed since time immemorial, but the operation of extraction, as performed at the present time, is of comparatively modern invention. Since Daviel, in 1745, described his method, the operation has undergone numerous modifications, the principal of which are as follows:

1. **Daviel** inserted his knife ½ millimetre from the edge of the sclera at the horizontal diameter of the cornea, making a flap of the entire lower half of the latter structure. He ruptured the anterior capsule of the lens, but did not perform any iridectomy.

2. **Jaeger,** the elder, performed practically the same operation, but made the flap of the upper half of the cornea.

3. **Jacobson** entered his knife through the cornea 1 millimetre below its horizontal diameter, also making the inferior flap at the corneal limbus. An iridectomy was performed in addition.

4. **Steffein's,** or the Moorfields Hospital (1878–'79) incision, was begun at the upper third of the cornea at the limbus. An iridectomy was also performed to aid in the extraction of the lens through the corneal incision.

5. **De Wecker's** operation differs from the foregoing in that the sclerotic tunic was involved to a slight extent. The knife is entered through the sclerotic 1 millimetre from the corneal limbus, passes through the anterior chamber on a horizontal line 2 millimetres from the upper edge of the cornea, and emerges through the sclera on the other side 1 millimetre form the corneal margin. The knife is brought upward with a to-and-fro movement until the blade emerges from the upper corneal margin. Iridectomy was not originally a part of this operation, but has since become incorporated with it.

6. **Lebrun** introduced a Graefe knife into the cornea at the limbus, about 1 or 2 millimetres below its transverse diameter,

and caused it to emerge at a similar point on the other side of the cornea. The cutting edge of the knife was turned upward, so that the plane of the blade formed an angle of 30 degrees with that of the iris. The knife was then drawn upward, still maintaining the angle with the iris, so that its exit was made in about the middle of the upper half of the cornea.

7. **Liebreich** returned to the original operation in part by extracting the lens through an incision in the lower portion of the cornea. His puncture and counter-puncture were made in the sclera 1 millimetre from the corneal limbus, and the plane of these punctures was 1 to 1½ millimetres from the lower margin of the cornea. The corneal flap thus made was necessarily small, but no iridectomy was performed.

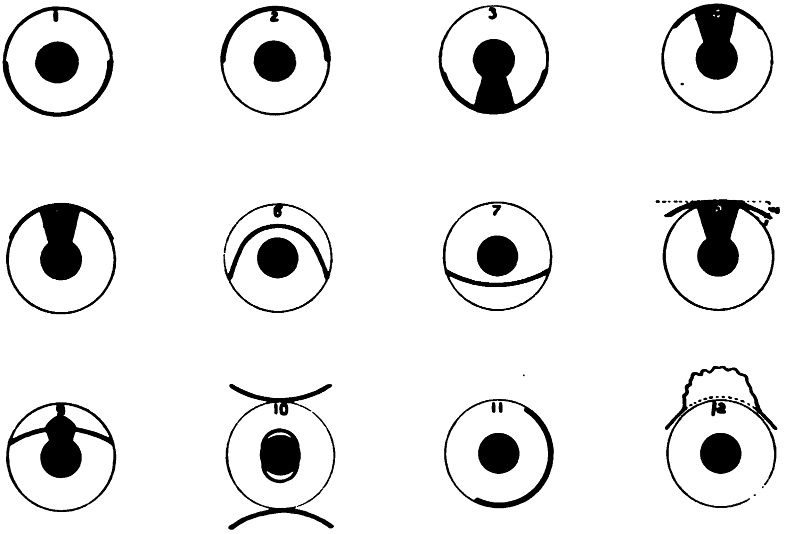

FIG. 136.—CATARACT OPERATIONS: 1, **Daviel**; 2, **Jaeger**; 3, **Jacobson**; 4, **Steffein**; 5, **De Wecker**; 6, **Lebrun**; 7, Liebreich; 8, Von Graefe; 9, **E. Jaeger**; 10, **Weber**; 11, **Wenzel**; 12, **Snellen.**

8. **Von Graefe's** operation is performed at the upper portion of the cornea. The puncture and counter-puncture are made in the sclera 1 millimetre from the cornea and on a line 2 millimetres below the extreme upper margin of the cornea. After the corneal incision has been made a portion of the iris is excised (iridectomy).

9. **Edouard Jaeger** devised an operation somewhat similar to that of Von Graefe, but made the corneal incision by means of a concave knife. The puncture and counter-puncture were made in the same plane, and the upper margin of the wound was made to lie within the cornea.

10. **Weber** performed his operation by means of a knife which bears his name. Either the upper or the lower portion of the cornea may be selected for the incision, which should involve but a small portion of the cornea at its centre. A small iridectomy should also be performed.

11. **Wenzel** transfixed the cornea diagonally, making the corneal flap partly at the side.

12. **Snellen** performs a superior section of the cornea with a conjunctival flap, with or without iridectomy.

The preceding operations are mentioned only to show a few of the various stages through which the operation of cataract has passed until it reached the present state of perfection. The operations described under Extraction through a Corneal Incision should be given the preference over those just enumerated.

CAPSULOTOMY

The author's favourite method for operating on posterior recurrent capsular cataract is as follows:

When the posterior capsule remains intact and obscures central vision, a secondary operation—capsulotomy—must be performed. The author prefers making an incision in the cornea with a broad needle, entering the capsule in the vertical direction. De Wecker scissors are then introduced through the corneal opening, and the blades separated, one blade passing behind the capsule, the other horizontally in front. With one snip the capsule is cut in two. This operation is most successful, giving a wide clear pupil. The capsule may also be lacerated with a Bowman's stop needle or a Landolt's knife.

DISCISSION

Discission with two needles may be required when the capsule is dense. In this case one needle is introduced through the nasal portion of the cornea into the opacity; a second needle is introduced in like manner through the temporal part of the cornea, directing the point of the second so as to meet the point of the first. A rent of sufficient width to insure useful vision is then made by separating the points of the needles. Tearing the capsule from its centre in this fashion with two needles, prevents traction on the ciliary bodies and avoids the possibility of cyclitis.

Single-needle discission consists in lacerating the anterior capsule of the lens with a needle. The operation is performed for soft cataract (lamellar, congenital, and some forms of traumatic): First, to promote absorption of the cataract by the entrance of the aqueous; second, to render transparent lens substance opaque to facilitate its removal by extraction.

The eye should of course be under strong illumination. It is fixed by fixation forceps and the lids held apart by means of a speculum. Atropine should be instilled into the eye several times before the operation in order that the pupil may be well dilated. In nervous individuals and children, general anæsthesia may be necessary; in the majority of cases, however, local anæsthesia by cocaine suffices.

The operator should face the patient. The eye is then well washed and a speculum introduced, the conjunctiva being seized with fixation forceps near the corneo-scleral margin, down and in on the left, and at the opposite situation on the right eye. A perpendicular puncture is made with a Bowman stop-needle in the lower and outer quadrant of the cornea in the left eye, and in the lower and inner quadrant in the right eye, midway between the centre of the pupil and the corneo-scleral margin. The needle is directed downward through the anterior chamber until its point is seen behind the centre of the pupil. Two sweeps of the needle's point are made in a vertical and two in a horizontal direction, to lacerate the capsule of the lens. This causes rapid breaking down of the cataract, and allows its particles which become separated to pass into the anterior chamber and later to become absorbed.

The operator must avoid stirring up the lens too energetically, and should withdraw the needle slowly.

We are indebted to the late Dr. J. C. Saunders, founder of Moorfields Eye Hospital (1804), London, for having suggested the discission operation. He also devised the delicate needle with which he so successfully operated. Sir William Bowman, many years afterward, modified the shape of this needle by placing a shoulder on it, and this Bowman's stop-needle, as it is now known, is almost universally used by ophthalmic surgeons.

The only complication which may arise in the needle operation is the too rapid swelling of the lens, which, by exerting pressure on the ciliary body, may cause cyclitis. When this occurs, it may be necessary to remove part of the soft lens by Teale's method—namely, making an incision into the anterior chamber through the upper third of the cornea, and sucking out part of the lens substance with a specially devised instrument, or by simple pressure.

The after-treatment is the constant application of iced cotton pledgets saturated in 1-to-2,000 bichloride-of-mercury solution, which are to be changed every half hour. The iris should be kept well dilated, and the ciliary body placed at rest by the instillation of 1 drop of atropine (1 grain to 3 dram solution) three times daily. Gray powder (mercury and chalk) should also be administered in 1-grain doses three times daily for one week. If violent inflammatory reaction takes place, the mercury should be increased to its physiologic limit.

Complications of all Cataract Operations.—Sometimes the corneal incision is too small to permit the easy exit of the lens. This may be due to poor judgment on the part of the operator or the presence of an abnormally large crystalline lens. In such cases the wound should be enlarged by a specially devised keratome, a blunt-pointed knife, or iris scissors. Any attempt to forcibly press a large lens through too small an opening is attended by contusion of the wound margins, and may be followed by suppuration. Such pressure may give rise to rupture of the zonula with subsequent loss of vitreous.

Hæmorrhage may occur from the iris or conjunctiva and often fills the anterior chamber. This can be expressed by gentle manipulation of the spatula upon the cornea, and further outflow of blood can be controlled in the instillation of adrenalin. The iris forceps may be used to remove any clots that may adhere to the wound margin.

Loss of vision may be due to a fluid condition of that humour or to the incision being made too near the periphery, thus depriving the zonula of its natural support. Excessive intra-ocular pressure brings about the prolapse of the vitreous. This may be caused by the pressure of the speculum or other instruments or by the patient straining. The occurrence of this complication before the lens has been extracted causes the latter to fall back into the vitreous, necessitating the employment of a Taylor's or Critchett's spoon. Loss of vitreous after the lens has been removed is not as serious a complication, but is always a danger signal. Vitreous opacities and retinal detachment may follow it.

A portion of the lens capsule may be left in the wound, and should be removed to prevent its becoming incarcerated in the wound during the healing stage. Its removal may be greatly facilitated by the introduction of a bent iris forceps, closed, into the wound, after which they are alternately opened and closed, withdrawing any shreds with which they come in contact.

The margins of the coloboma of the iris may become prolapsed into the corneal incision during the expression of the lens, and if allowed to remain so there will be bulging and upward retraction of the pupil. To avoid this, the spatula should be introduced into the corneal wound in every case to make certain that its margins are free, and the iris should be stroked downward.

Pain may be experienced during the first twenty-four hours, but is readily relieved by the hypodermic injection of morphine. Opium (gr. j) combined with calomel (gr. ij) or trional may also be used for the same purpose.

The anterior chamber may not reform until a week has elapsed from the time of operation. This is unusual, and should this condition persist for a longer period the corneal wound should be searched for shreds of the capsule, as these are usually the cause. The condition is not serious unless the iris has become incarcerated in the wound. Removal of all interfering particles is indicated, as they prevent recovery.

Suppuration of the wound may follow uncleanliness as regards instruments and solutions used, but is more often due to the presence of undetected lacrymal disease. It begins during the first forty-eight hours, and is attended by continuous pain and purulent discharge. This is a very serious complication, and may result in destruction of the eye. It receives the same treatment as other suppurative ocular inflammations. Cauterization of the corneal wound and the opening of the incision, thereby affording an exit for the aqueous, have been highly recommended in this condition. Irrigation of the anterior chamber with bichloride-of-mercury solution (1 to 10,000), with intra-ocular or subconjunctival injections of the same solution, have also been employed. The prognosis in this complication is extremely serious.

Striped keratitis may occur after cataract extraction. It is attributed to injury to the cornea by instruments, or the introduction of strong antiseptic solutions into the anterior chamber. It usually passes off in the course of a few days, but may remain as an opacity and greatly obstruct vision.

Iritis nearly always accompanies suppuration of the corneal wound, but may arise independently of that affection from irritation by some of the lens matter or from infection. It does not make its appearance until about the fourth day after the operation, and is ushered in by considerable pain. The inflammation is plastic in character, and may extend to the ciliary body and induce sympathetic ophthalmia in rare cases. The exudate into the pupil is often considerable, and obstructs vision to a great degree. The treatment is that of iritis under other circumstances.

The cicatrix at the corneal wound occasionally undergoes a cystic change and appears at the end of several weeks as a transparent vesicle. It is induced by incarceration of a portion of the iris, lens-capsule, or cortical matter in the corneal wound during the process of healing. It is not necessary to remove this vesicle. As its results may be mentioned irregular astigmatism, displacement of the pupil, iritis, iridocyclitis, and iridochorioiditis.

Glaucoma may follow cataract extraction, and is usually preceded by iritis with a plastic exudate. It also follows discission.

Retinal hæmorrhages occur in some cases and make their appearance upon the third day after operation. They are most frequent in those of hæmorrhagic diathesis.

Delayed healing of the margins of the wound after the extraction of senile cataract in persons of seventy-five years of age and upward is also encountered. The application of silver nitrate (25 per cent solution or the solid stick) should be made to the edges of the entire wound. There is no violent reaction, as would be expected.

After-treatment.—Both eyelids should be closed and covered with a generous amount of petrolatum, after which the small gauze pads and the large pad is applied and held in place by adhesive straps. A perforated aluminum guard or shield is then fastened over the eye operated upon. All pieces of cotton and threads of gauze should be removed from the ears and face of the patient, as they are irritating and often cause the patient to unconsciously interfere with the dressing. Rest in bed in a darkened room for three or four days is always advisable. The first twenty-four hours milk should be the diet, and a nurse should be in constant attendance during that period if possible. The first dressing should be made at the end of twenty-four hours, and if everything is favourable a more upright position in bed may be assumed and soft diet allowed. At the end of three days the unaffected eye may be left without bandaging, and at the end of a week the bandage is taken off the eye operated upon one hour, on the eighth day two to four hours, on the ninth day and afterward the eye is left open all day, being guarded by the bandage only at night. After this period dark glasses should be worn. When the eye is first exposed in many cases the light seems red to the patient, and the term erythropsia is applied to this condition. Green or blue vision may also be encountered.

The refraction should be examined at the termination of six weeks from the operation, and again at intervals of two weeks until the astigmatism and its axis have become stationary; when this has occurred the glasses are ordered for distance, with an additional convex lens for near work to take the place of the accommodation. If the vision is not improved by the use of convex lenses, the fault usually lies in the presence of an after-cataract in the pupillary area. Needling will be required for this, but is not advisable until about three months after the extraction operation.

RULES GOVERNING CATARACT OPERATIONS

If one eye alone is the seat of cataract and vision is normal in the other eye, operative interference to a large extent is contraindicated on account of the difficulty in obtaining perfect binocular vision; but then again it is indicated for the reason that the enlarged visual field obtained compensates for the temporary annoyance occasioned by the binocular diplopia. In young persons, however, it may be desired on account of the marked deformity the opacity produces by its white glistening appearance.

When vision is lost in one eye as the result of other affections, and cataract is beginning in the other, extraction should not be hastened, but should be deferred until the conditions most favourable for its performance—i. e., maturity—are present.

In double lenticular cataract with loss of useful vision, extraction should be performed upon the eye in which the cataract is most matured. Operations should not be performed upon both eyes at the same sitting.

In congenital cataract the operation should be performed as early as is compatible with the child's general health, so that he may become educated as to the nature of surrounding objects.

The presence of erysipelas or other infectious diseases, lacrymal affections, bronchitis, ocular inflammations, corneal opacities, vitreous opacities, etc., are contra-indications for cataract operations.

Immaturity of the cataract is always a contra-indication for extraction. The field of vision should be normal and light perception should be intact. Operation in the absence of these symptoms is not attended by favourable results, owing to disease of the chorioid, vitreous, retina, or optic nerve.

CHAPTER XIII

DISEASES OF THE VITREOUS

In order to fully understand the pathological changes which are likely to occur in this structure, it is necessary to briefly review its anatomy. The vitreous, or *corpus vitreum,* is made up of two distinct portions. The greater portion is aqueous in character and constitutes about 98.6 per cent of the whole structure. The solid constituent is composed of transparent fibres which extend in all directions and hold the watery element in the interspaces formed by them. The importance of these portions of the vitreous is manifest in penetrating wounds of the eyeball, the aqueous element having all the qualities of a good culture medium for the propagation of pathogenic bacteria. The consistency of the vitreous in the normal state is a trifle less than that of ordinary jelly, and serves to maintain a depression on its anterior surface, the *fossa patellaris,* in which the posterior surface of the crystalline lens rests. At the periphery of the vitreous are cells of peculiar shape and size known as amœboid cells. Some are adherent to the fibres, while others float freely in the humor. They are believed by some to be the origin of the muscæ volitantes. Traversing the vitreous in its central portion from behind forward is a lymph-space 2 millimetres in diameter known as the ***hyaloid canal,*** which extends from the head of the optic nerve to the posterior surface of the lens. During fœtal life this is occupied by the hyaloid artery, which occasionally persists. The external limiting membrane of the vitreous is a structureless layer known as the *hyaloid membrane.* There are no blood-vessels in the vitreous body, its nutrition being derived from surrounding tissues. It is transparent normally, and has an index of refraction of about 1.3340. Its function is to maintain the shape of the eyeball, support the ocular tunics, and afford a transparent medium of the dioptric system. It may be readily seen that independent disease of the vitreous is not likely to occur, and that most of its affections are secondary to those of the uveal tract, from which it is nourished.

INFLAMMATION OF THE VITREOUS BODY

Hyalitis.—*Definition.*—Hyalitis is an inflammatory condition of the entire vitreous humour. It seldom if ever occurs as a primary affection, and is attended by the formation of pus in most cases.

Causes.—Arising as a secondary affection, its causes are those of the primary disease. A low state of the general health is an important factor in its production by lessening the resistance of the vitreous to microbic infection. In most cases the introduction of pus-producing micro-organisms is the principal cause, particularly in those instances in which the inflammation follows penetrating wounds, foreign bodies in the eyeball, and chorioiditis after the infectious fevers, such as scarlet fever, erysipelas, etc. The inflammation is often preceded by retinitis, uveitis, irido-chorioiditis. Spontaneous hyalitis has been said to occur, but this remains very much in doubt.

Varieties.—Suppurative and non-suppurative.

Suppurative or purulent hyalitis most frequently arises from the proliferation of pathogenic bacteria introduced into the vitreous through penetrating wounds of the eyeball or by means of the blood-stream. This accounts for the inflammation that follows foreign bodies in the eyeball, and injuries, and for those apparently obscure cases that occur in the course of scarlet fever, typhoid fever, cerebrospinal meningitis, erysipelas, etc. The manner in which this affection is brought about is not always clear, and it must be remembered that in most instances the chorioid and the hyaloid membrane are first attacked.

Symptoms.—In all cases there is inflammatory reaction of the whole eyeball proportionate to the injury and the involvement of its various structures. An opacity naturally results from the pus that has accumulated in the vitreous humour. This opaque appearance may either be circumscribed or diffuse, the latter condition being the more frequent. When the cornea remains unaffected or transparent, it may be observed that the vitreous presents a yellowish reflex shining through the pupillary space. The pupil may be dilated, due to a retraction of the iris, and posterior synechiæ are formed, due to inflammation of the iris. In the more advanced stages of suppurative hyalitis it may be impossible to examine the fundus on account of the large amount of pus. The change in the consistency of the vitreous causes a diminution in the tension of the eyeball.

The presence of iritis and irido-cyclitis may be detected by the synechiæ found, the irregular movement of the pupil, and the deep pericorneal injection.

In those cases in which the pus is markedly circumscribed an error in diagnosis is likely to occur if a careful examination is not made. In such cases the yellowish reflex from the pupil suggests glioma in children, and for this reason circumscribed collections of pus in the vitreous are termed pseudoglioma. They occur most often at the periphery of the chamber near the ciliary region. The tension is always decreased and the symptoms of iritis or irido-cyclitis are very prominent, and these, together with the history, should serve to differentiate the two conditions.

The diffuse form of hyalitis has a tendency to become chronic, when the prognosis is especially unfavourable. Shrinking of the exudate follows in those cases in which the eye is not immediately destroyed, resulting in detachment of the coats, rendering the eye a useless organ. Cases of hyalitis, the result of traumatism, have been reported to have made complete and uneventful recoveries. Such cases are, however, very rare.

Treatment.—This varies with the character of the inflammation and its primary cause. If the disease is part of a panophthalmitis, following a penetrating wound, enucleation is necessary at once; but if the disease is not so marked and arises from some general infection, mercurial treatment may be of great benefit. However, even in these cases, the shrinking of the purulent exudate after the subsidence of the inflammation will necessitate enucleation at a later period. The discovery of the disease in its early stage is always difficult, but when it is suspected, the free administration of tonic remedies, particularly mercury, may aid in retarding its progress.

The non-suppurative form of hyalitis is subacute or chronic in character, and is always secondary to chronic inflammation of the retina or chorioid. The vision is reduced by reason of the retinal or chorioidal disease and the pathological opacities in the vitreous. These opacities should not be confounded with the *muscæ volitantes*, which are to a great extent normally present. The opacities of the vitreous in hyalitis are due to disintegration of that structure, and their free movement is rendered possible by the change in the consistency of the vitreous. Their presence can be readily detected by means of the ophthalmoscope. The appearance they present varies from a dust-like mist to thin membranous bands. The method of locating these opacities has been discussed in describing the ophthalmoscope.

Causes.—The most important conditions which may give rise to this form of hyalitis are ametropia, myopic in character, disease of the neighbouring structures, hæmorrhage into the vitreous, and constitutional diseases, such as syphilis, gout, rheumatism, anæmia, exhausting fevers, etc. Occasionally the affection arises without any apparent cause. This is most frequent in elderly individuals.

Symptoms.—Disturbance of vision is always present, the degree varying with the extent of the disease and the character and location of the opacities. The spots are frequently seen by the patient and occasion considerable annoyance.

Treatment.—In all cases the refraction should be examined and the correcting lenses should be ordered. This alone frequently causes a cessation of the annoyance which the floating specks occasion. The cause should be ascertained and the treatment directed towards it.

The mixed form of treatment and the free use of tonics and stimulants are commendable at all times. The application of leeches to the temple may be of value. The use of electricity in the form of constant current has rendered invaluable results. The subconjunctival injection of saline solution (sodii saccharat, gr. xv to ℥j) in the hands of the author has met with encouragement, 10 to 20 cubic centimetres of the saline solution being injected in very severe cases, every second day. The pain is considerable, but may be controlled by the use of an antiphlogistic application. The use of intraocular injections of chlorine water has failed to give the results at first attributed to it. Attention to the personal hygiene of the patient should always be insisted upon, as much aid can be derived from a small amount of care in this respect.

Prognosis.—Relapses are likely to occur in this variety, although response to appropriate treatment may be prompt at first. In the hæmorrhagic opacities absorption seldom occurs without damage to the eye.

OPACITIES IN THE VITREOUS

The formation of opacities in the vitreous may be a physiological or pathological process. Among the physiological opacities may be mentioned the various forms of muscæ volitantes. The pathological opacities include foreign bodies, blood pigment, cholesterin and tyrosin crystals, parasites, inflammatory exudate, and morbid growths penetrating the vitreous.

Muscæ volitantes are opaque specks of various size and shape which float before the sight, particularly where the eye is directed towards a bright light. They may also be seen when the eyes are closed. Vision is not particularly interfered with by their presence, but considerable annoyance is occasioned by their movements. Their derivation is in doubt, but it is probable that they have their origin in the amœbæ-like cells at the periphery of the vitreous. They cannot be detected by the ophthalmoscope.

The pathological opacities may be derived from without or originate within the vitreous body itself. Nearly all these opacities are introduced from without with the exception of those due to disintegration of the vitreous, as in the case of cholesterin, tyrosin, and other crystals. The shape of these opacities admits of wide variation; some being minute dots or arranged in dust-like aggregation, while others are elongated or thread-like. Those following hæmorrhage are more or less membranous, while those due to parasites or tumours encroaching upon the vitreous are very large in size and usually yellowish-white in colour.

The symptoms are subjective and objective. Subjective symptoms include all the disturbance of vision occasioned by the opacities. The objective symptoms are those brought out by ophthalmoscopic examination and consist of the numerous reflexes or shadows caused by the opacities. Their size, shape, and location may also be determined in this examination.

The mobility of the opacities should always be determined, as it is proportionate to the fluidity of the vitreous. Those which are fixed are usually attached to the retina, chorioid, or ciliary processes. If the movement present is very slow the condition of the vitreous is normal, but as the movement increases in rate the consistency becomes altered to a corresponding degree.

Treatment.—The treatment should be directed to the cause of the opacities or the disease with which they are associated. If no assignable cause can be discovered, careful attention should be given the patient's general health. Alteratives, especially mercury, potassium iodide, etc., in small but long-continued doses may be of great value. Diuretics and diaphoretics may also be beneficial. Hot baths, 105° to 120° F., followed by hot-packs every second day may be of service. Subconjunctival injections of normal saline solution are most valuable.

Prognosis.—This varies greatly according to the cause. In the case of muscæ volitantes the outlook is very favourable, as they are unconnected with any disease of the eye. Foreign bodies in the vitreous are nearly always followed by a violent inflammatory reaction that may cause the eye to be lost. Inflammatory exudates and blood pigment often leave behind connective-tissue bands, which by their contraction cause shrinking of the globe. Fatty crystals in the corpus vitreum are of no serious import in themselves, but suggest retrograde changes in the vitreous, and consequently contra-indicate operations of any kind on the eye. Parasites and morbid growths eventually destroy the usefulness of the eyeball. In all varieties the vision is reduced according to the size of the opacity, but the annoyance to which it gives rise is in indirect proportion to the size of the opacity.

Hæmorrhages into the Vitreous.—Owing to the absence of blood-vessels in the vitreous, hæmorrhage into it is always derived from the vessels of the retina, chorioid, or ciliary body. Injury to the head or eyeball is the most frequent cause of this condition, and in well-marked cases it is manifested by great disturbance of vision. Oftentimes the hæmorrhage is so large that the chamber is filled and the retinal reflex is absent or obscured. Spontaneous hæmorrhage into the vitreous is not rare, and arises from disease of the blood or ocular blood-vessels. The blood diseases, such as scurvy and purpura, may be responsible in certain cases. Chronic inflammation of the vessel walls from gout, rheumatism, and allied affections is a more frequent cause. Any sudden rise of blood pressure in individuals so affected may precipitate apoplexy of the vitreous in the same manner as in other structures. Vicarious menstruation may take place into the vitreous in very rare instances. The diagnosis is made largely by the obscuration of the retinal reflex in the ophthalmoscopic examination. The vision increases as absorption takes place, which is seldom complete, membranous masses and pigment often remaining. The outlook in every case depends upon the degree to which absorption occurs.

Treatment.—The patient should be placed at absolute rest in bed with the head highly elevated. Such active measures, as cold compresses, should be applied to the eye, depletion by means of leeches, and cardiac sedatives should be instituted. The presence of syphilis, in any form, indicates the use of mercury or the iodides, or both.

During the first stages, or as soon as possible after the hæmorrhage has occurred, diaphoretic and diuretic agents should be given, and in small frequently repeated doses. The diuretics usually employed are the compound syrup of squill and calomel. The system meanwhile should be drained of the excess of blood-serum by the frequent administration of the sulphate of magnesia. The administration of fluid extract of ergot and gallic acid has also proved very beneficial in such cases. Iodide of potassium should be given early in all cases on account of its absorbent properties.

Alterations in the Consistency of the Vitreous.—The consistency of this structure admits of two variations: increase and decrease. Increased consistency probably exists in those conditions in which all the fluids of the body undergo an increase in their solid constituents, but its presence has yet to be demonstrated. A far more frequent condition is decreased consistency. This is also known as synchysis or fluidity of the vitreous. It is accompanied by chorioidal disease, and is manifested by diminished tension of the eyeball, rapid movement of vitreous opacities, and tremulousness of the iris. The importance of this condition arises from the fact that it occurs in elderly persons in whom cataract is also frequent, and any operation in such cases is likely to be followed by loss of vitreous and collapse of the eyeball. There is no treatment.

Degeneration of the Vitreous.—This is manifested by fluidity of the vitreous body and by the formation of crystals of leucin, tyrosin, cholesterin, etc. The presence of these crystals is termed *synchysis scintillans.* It is a pathological condition, and may be distinguished from *muscæ volitantes* by the glistening reflex seen by the ophthalmoscope. The appearance they present is not unlike that of a shower of silver specks. They are derived from the blood directly or indirectly and accompany other degenerative conditions, although vision may not be altered to any great extent.

As a late result of degenerative changes, the vitreous may undergo contraction and shrinking, giving rise to detachment. This renders the eye useless, but interference is unnecessary unless inflammatory symptoms occur, when enucleation is indicated.

ANOMALOUS CONTENTS OF THE VITREOUS

Under this heading may be conveniently described those conditions which are not, strictly speaking, diseases, but are abnormal affections. These include blood-vessels, persistent hyaloid artery, parasites, foreign bodies, and growths.

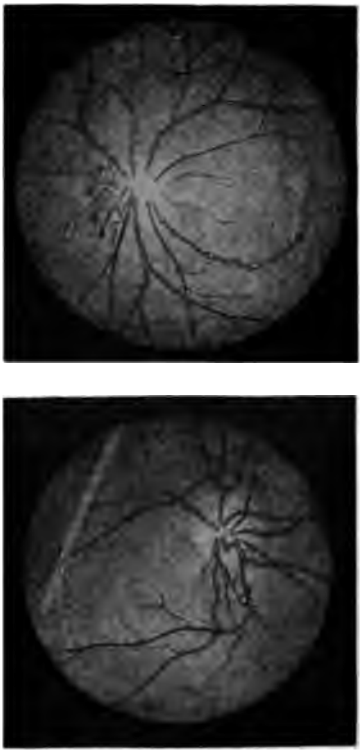
FIG. 137.—NEWLY FORMED BLOOD-VESSELS IN VITREOUS. (Author's cases.)

Blood-vessels in the vitreous are rare, and when present are nearly always localized to the head of the optic nerve, sometimes obscuring it. They are of no special pathological significance.

Persistent Hyaloid Artery.—The hyaloid artery usually disappears during the latter period of fœtal life. In some extremely rare cases, however, remains of this artery in the vitreous have been traced by careful ophthalmoscopic examinations, either in the form of a short, dark stripe, or of a dark thread running through the vitreous from the optic disk towards the posterior pole of the lens. One case was noted in which the artery carried blood, appearing as a red cord-like structure by incident light. Liebreich has reported a case in which there existed a physiological cupping of the optic nerve, together with a persistent hyaloid artery, the latter being distinctly traced up to its point of origin—the central artery of the retina. A case, a boy sixteen years of age, came under the observation of my assistant, Dr. F. K. Brown, at the Medico-Chirurgical Hospital, in which a transparent hyaloid canal existed in the left eye. In this case a small arterial twig took its origin in the central artery of the disk, running, with a slight bend, some distance into the vitreous humour of the eye, and then making a loop, returning and twisting itself three times around its base like the tendril of a grape-vine, terminated apparently in one of the large central veins.

Parasites in the Vitreous.—Filaria, hydatids, and cysticercus have occasionally been observed in the vitreous. Sight is always impaired, the interference being proportional to the number of parasites infesting this body.

On examination of the cysticercus it is found to present a bluish-white appearance. Following its death the parasite is found to be so covered with lymph as to be rendered recognisable by the aid of the ophthalmoscope, and if the parasite is not removed, sight may be lost and the eyeball undergo atrophic changes. The author remembers, while a student in Vienna, a case which came under the observation of Professor Arlt. An effort was made to remove it, which was unsuccessful. Its movement could be readily seen with the ophthalmoscope. The author has never seen a case in this country. They are mostly observed in Germany or Austria.

Foreign Bodies in the Vitreous.—It is very interesting to note the numerous foreign bodies that may enter this region, and of still greater interest are the various results that are likely to follow after their entrance.

If a foreign body becomes lodged in the vitreous it very frequently causes a most severe and destructive inflammation of the tissues through which it found entrance, or with which it lies in contact. If it has entered through the cornea, this body, as well as the iris, often becomes violently inflamed; the lens, through which it must have passed, becomes greatly swollen and cataractous, thus tending to further increase the severity of the inflammation. When the foreign body lies in the vitreous and close to the retina a severe inflammation of the retina is quite frequently produced as well as inflammation of the chorioid, which may perhaps lead to atrophy of the globe. In a short time after the foreign body has entered the vitreous the latter becomes clouded, especially in the neighbourhood of the foreign body; later the foreign body becomes encysted, and the vitreous becomes diffusely clouded and filamentous opacities float about in it, thus causing a great disturbance of vision.

Although the unfavourable results just mentioned must be considered as possibilities in all foreign-body cases, they are not as frequent as the modern text-books would seem to indicate. In my own experience I have observed a number of cases in which the foreign body after entering the vitreous produced very little reaction, and even in the case of large bodies the results predicted have not always taken place. In one patient a needle of steel passed through the cornea, iris, lens, and vitreous and embedded itself in the posterior portion of the eyeball in the retina, where it could be easily seen by means of the ophthalmoscope. Its track was shown by a delicate line of scar-tissue. When the patient came under my charge at the Medico-Chirurgical Hospital several weeks had elapsed since the occurrence of the accident and the eye was comparatively quiet. The foreign body was subsequently located by the X-ray. In another case the patient was shot in the face, the shot entering the eyeball. Hæmorrhage followed immediately and vision was reduced to the perception of hand-movement at a few inches from the eye. The patient was treated by his family physician, Dr. Glendon, of Cedarville, N. J., for three weeks by the ordinary methods for combating inflammation. The vision improved during this period and continued to improve, so that when I last heard from him it was $\frac{6}{6}$ for distance, and he was able to read the newspaper with comfort. The patient was brought to me for an opinion as to the advisability of enucleation on account of the foreign body in the eye. Upon careful examination of the eye it was found that the shot had penetrated the sclerotic just above the upper line of the external muscle, a short distance in front of the equator. By extreme convergence another opening could be distinctly seen on the same line, but just behind the equator, showing by the indenture and chorioidal staining that the shot had gone in and then out through the sclerotic coat and buried itself deep in the orbit. This was subsequently confirmed by the X-ray. Enucleation was, therefore, not advised.

There are still other cases in which, although the injury may be followed by severe inflammation, the foreign body will become encysted, and the vitreous humour gradually regains its transparency after the subsidence of the inflammatory symptoms.

Quite frequently, after a foreign body has remained encysted and dormant for a number of years, it may give rise to inflammatory symptoms, which may lead to atrophy of the globe, or produce sympathetic ophthalmia.

The resistance of an eye containing a foreign body, or through which one has passed, is always lessened and requires surveillance, as it is likely to become seriously inflamed at some remote period from the most trivial cause.

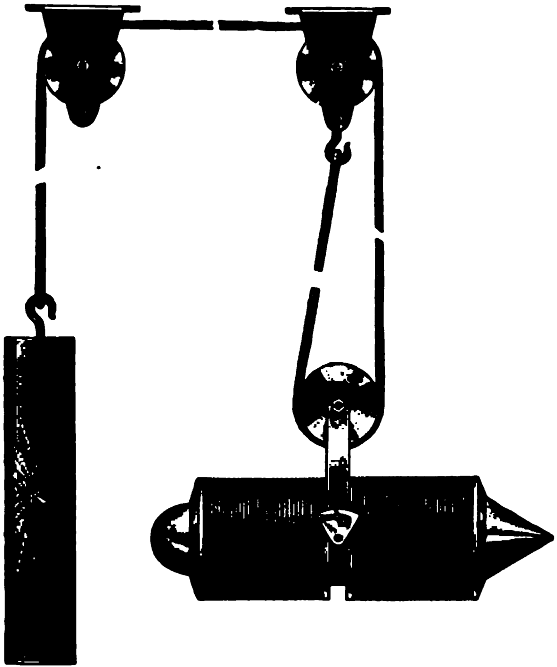

FIG. 138.—HAAB'S MAGNET.

Treatment.—If the position of the body can be determined, and its removal is even remotely possible, the attempt should at least be made. If the fragment be of metallic nature, removal by the electric magnet may be practicable; if the body quivers on the approach of the magnet the indications are favourable for removal by this means. The needle may be introduced through the original wound, or a new incision made through the sclerotic close to the location of the foreign body. The position of the patient's head must be carefully considered if the foreign body moves with motions of the head, and it is sometimes necessary to perform the operation with the patient seated. Should the foreign body be located in the lens, this structure should be immediately removed, as in cataract operation. If the fragment is located directly behind the lens, its removal may be effected at the same time, or immediately after the removal of the lens. If the foreign body can only be removed by sacrificing the lens, this sacrifice should be made, since a foreign body in the vitreous rarely fails to set up hyalitis or glaucoma; it may also produce retinal detachment or give rise to sympathetic ophthalmia, as already mentioned.

Cold compresses should be applied to the eye and leeches to the temple, with the view of allaying the attendant intense inflammation. The pupil should also be dilated to its full extent, and the eye placed at rest by the local administration of atropine, and if a suppurative iritis or irido-cyclitis supervenes, it may be necessary to administer mercury. These measures are, of course, to be resorted to before the operation has been performed.

Growths such as glioma and sarcoma may occupy the vitreous chamber prior to their rupture through the globe. The vitreous is displaced and vision is reduced as the growth increases. An alteration in the pupillary reflex is suggestive of such conditions. They are fully considered elsewhere in this work.

CHAPTER XIV

GLAUCOMA

THE term glaucoma was first used by Hippocrates, and was applied to all opacities located posteriorly to the pupil. Later on the term was used in a more restricted sense, being limited to those eyes which, when viewed through the dilated pupil, presented a green reflex. The cause of this reflex, however, was not understood. The disease was believed to be incurable.

Some of the earlier physicians claimed that the disease had its seat in the vitreous humour, while others held that the real seat of the affection was in the retina and optic nerve. At a still later period it was believed that glaucoma was due to a peculiar inflammation of the chorioid, which occurred most frequently in gouty or rheumatic individuals. This view gave rise to the term "arthritic ophthalmia," which is still used by a few writers.

The characteristic symptoms of this affection were not generally recognised by physicians until the advent of the ophthalmoscope, which was invented by Helmholtz in 1851.

Mackenzie, in his valuable work on Diseases of the Eye,[1] gives a very good description of glaucoma, which is not so widely at variance with modern views on the subject. The increased tension of the eye in glaucoma was pointed out by him in 1830. In the treatment of this disease he mentions puncture of the sclerotic with a broad iris knife. He also suggested puncturing the cornea and evacuating the aqueous humour, and stated that this procedure resulted in temporary improvement of vision, as well as relief of the pain. Removal of the crystalline lens is also mentioned by him. He says this procedure sometimes improves the vision of the patient. The beneficial results following this operation are, in the light of our present knowledge, evidently due to the fact that the wound made in the eye acts as a filtration channel, and relieves the hypertension.

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[1] P. 899, 1854 edition.

Many points, however, were still needed to complete the symptomatology and diagnosis of glaucoma, and the brilliant von Graefe was the first to supply these points and advance the modern theory of glaucoma. Not only, however, did he accurately describe the disease, but planned an operation which rendered the cure of this hitherto incurable affection possible.

Von Graefe pointed out the presence of arterial pulsation in the optic nerve in glaucoma, which pulsation, he observed, was either spontaneous, or might be produced by slight or moderate pressure on the eyeball. At the same time he discovered the cause of the peculiar appearance of the optic disk, which, together with other observers, he had previously ascribed to an arching forward of the optic nerve-fibres at their entrance, but which in reality is due to a pathologic excavation or cupping of the disk at this point. He at once recognised the important connection between the excavation and arterial pulsation, and the increased tension of the eyeball.

In his endeavour to prevent or permanently lower this increased tension he first employed the usual remedies—mercurials, antiphlogistics, diuretics, and diaphoretics. This treatment proving unsuccessful, myotics were next employed, it being known that these drugs decreased intra-ocular tension. These drugs, however, only gave temporary relief. He next decided upon paracentesis; this operation, also, was followed by only temporary improvement.

Having previously observed that ulceration and infiltrations of the cornea, partial staphyloma of the cornea, and staphyloma of the sclerotic were cured, or at least improved, by an iridectomy, he decided to perform this operation in glaucoma for the purpose of lowering the abnormal tension. He first performed an iridectomy for glaucoma in June, 1856, and found that not only was the intra-ocular tension permanently diminished, but that, indeed, the operation might be regarded as a true curative measure in this disease. The results obtained are world-renowned, and the most eminent ophthalmologists consider this operation the only cure for glaucoma.

Glaucoma may be described as a morbid condition of the eye, characterized essentially by abnormally increased intra-ocular tension and pathologic cupping of the optic disk, and terminating in blindness if untreated.

Theories of its Production.—Many different theories have been advanced by leading authorities to explain the cause of the abnormally increased intra-ocular tension in glaucoma. Thus far, however, only two are worthy of serious attention. These may be termed the theory of hypersecretion and that of retention of the intraocular fluids.

The hypersecretion of fluids is caused by irritation of the nerves governing the secretory functions. The simplicity of this theory is beautiful, but when, however, we attempt to explain the manner in which the fluids are retained the problem becomes more difficult.

It is a well-known fact that effete fluids pass out of the globe principally by way of the ligamentum pectinatum and canal of Schlemm. But in glaucomatous eyes it is found that the periphery of the iris lies in contact with the cornea, thus damming the outlet. This theory of retention has, at the present time, the greater number of supporters, although it is open to severe criticism.

Priestly Smith has advanced the most ingenious and able as well as the most plausible explanation of the mechanism of retention. He claims that there is a narrowing, or even an obliteration, of the canal of Petit, the space situated between the edge of the lens and the ciliary process; this is caused by an enlargement of the lens, which always takes place in old age. Petit's canal is the route through which the excreted fluids of the vitreous chamber pass forward to the canal of Schlemm. If, therefore, Petit's canal be blocked, the increased pressure from behind will push the lens forward and shut off the canal of Schlemm by the iris, as mentioned above, a point which was left unexplained by previous theories.

Among other theories that have been advanced may be mentioned rigidity and shrinking of the sclerotic, swelling of the ciliary processes, etc.

Classification.—For purposes of study glaucoma may be considered as congenital or acquired.

Congenital glaucoma may be subdivided into simple glaucoma and buphthalmos (or keratoglobus).

Simple glaucoma of congenital origin is characterized by blindness, cupping of the disk, increased tension, and shallow anterior chamber, but no pain or other acute symptoms. Vision is greatly reduced. Treatment is that of ordinary simple glaucoma.

Buphthalmos, in addition to increased tension and the other characteristics of glaucoma in general, is distinguished by marked protrusion of the eyeball, and particularly of the cornea. At birth the protrusion may be slight, but increases gradually until enormous dimensions are reached. The protrusion, being anteriorly and affecting the cornea to a great extent, has caused the name keratoglobus to be applied to the condition, which is also described under that name in the chapter on Diseases of the Cornea (*q. v.*). As the corneal protrusion is but a symptom of the congenital glaucoma, it will be considered more in detail in this description. The sclera is greatly thinned by the stretching to which it is subjected by the high intra-ocular pressure, so that the pigment of the uveal tract shows through, causing it to assume a bluish-gray colour. The depth of the anterior chamber is greatly increased and the iris is more or less tremulous, due to the weakening of the suspensory ligament of the lens and the diminution in the consistency of the vitreous. The cupping of the disk is marked. Vision is greatly diminished from the beginning, and blindness is the usual termination.

The underlying cause of the condition is the subject of considerable discussion. According to Treacher Collins, the affection is due to a congenital malformation in the channels of exit for the ocular fluids. This is supported by the fact that in some cases it is possible to demonstrate the absence of the canal of Schlemm. By other observers it is believed that a prenatal kerato-iritis is the underlying cause by blocking the channels of exit by the attendant adhesions.

Treatment.—Owing to the changes in the various structures of the eye, the operations of iridectomy and sclerotomy are not attended by the uniformly good results as otherwise, and frequently fail to lessen the tension or to prevent further enlargement of the globe. Dislocation of the lens and loss of vitreous are common complications. Less dangerous methods of treatment consist in the instillation of myotics and paracentesis. Incision of the adherent tags of tissue which block the various channels at the angle of the anterior chamber, by passing the point of a knife into its extreme angle, has also been suggested. Enucleation, however, becomes necessary when the deformity is marked, as the eye in these cases is useless as a visual organ.

Glaucoma may be said to be primary or secondary.

Primary glaucoma is that variety which arises without any obvious cause, but the influence of certain predisposing factors in its production is well known, and should never be completely ignored.

Age is of great importance in this connection, as the condition is most frequent at the extremes of life. It may be prenatal or date from birth, as was readily seen in the consideration of congenital glaucoma. During early adult life the affection is seldom observed except those cases of congenital origin, and it may be considered as extremely rare under thirty years of age. With the advent of presbyopia primary glaucoma gradually increases in frequency, until at sixty years its occurrence may be looked upon as rather common.

Although sex should not influence glaucoma to any extent, it is a clinical fact that women are affected with greater frequency than men, and the liability to acute attacks is also greater in these individuals.

Heredity exercises slight influence upon the production of glaucoma, as cases have been recorded in which several members of the same family, extending over two or three generations, had been affected.

Race is said to have some effect in predisposing to the condition, and it has been repeatedly stated that Jews, Egyptians, and negroes are most liable to glaucoma. It can be readily seen that deductions from observations in this connection depend entirely upon the geographical location of the observer.

Refraction is an important predisposing factor. About one-half of all the cases of primary glaucoma occur in individuals the subjects of hyperopia, and in it high myopia is extremely infrequent. Prolonged near-work with excessive functional activity of the ciliary muscle in hyperopic persons also predisposes to glaucoma. In these cases the attack is usually precipitated by the instillation of atropine or some similar cycloplegic, so that in persons past forty or forty-five years of age it is a good rule to avoid the instillation of these drugs in order to prevent this complication.

The size of the cornea is of importance, as those corneæ having a horizontal diameter of less than 10 millimetres seldom escape glaucoma.

Among the remaining predisposing factors may be mentioned grief, loss of sleep, shock from operation upon the other eye, local injuries, such as abrasion and ulcer of the cornea, facial neuralgia, cold, fatigue, constipation, circulatory and pulmonary affections, etc.

Secondary glaucoma always follows some pathological condition of the eye that results in obstructing the angle of the anterior chamber. Among these may be mentioned iritis and its sequels, congenital absence or coloboma of the iris, serous cyclitis, anterior synechiæ of the lens-capsule, or hyaloid membrane of the vitreous after cataract extraction, wounds and luxation of the crystalline lens, intra-ocular tumours, cysts in the anterior chamber, retinal detachment, thrombosis of the retinal vein, hæmorrhagic retinitis, etc.

Glaucoma may also be divided into inflammatory and non-inflammatory glaucoma.

Inflammatory glaucoma, as the term indicates, is attended by congestion or inflammation of the ocular tissues, and includes *acute* and *chronic glaucoma.*

Non-inflammatory glaucoma is characterized by the absence of inflammatory phenomena, and is typified by *glaucoma simplex.*

Acute or Inflammatory Glaucoma.—In this form of glaucoma there is held to be a group of premonitory symptoms, but it is hard to understand how these symptoms can appear before an actual increase of tension has taken place. Among these so-called premonitory symptoms are sudden failure of power of accommodation, fogginess of vision, and coloured halos about the sources of light.

The cornea is somewhat cloudy in its central portion, and the anterior chamber is shallow in this prodromal stage. In addition may also be mentioned the sluggish dilated pupil, the slight increase in the intra-ocular tension, and the circumcorneal injection. The patient also complains of headache and ocular pain. By far the most common prodrome is the rapid failure of accommodation, so that a marked increase in presbyopia should always excite suspicion.

The duration of these phenomena may vary from a few hours to several days, usually subsiding only to recur with renewed vigour at a later period. At first the attacks are few in number, but later they become more numerous, although they may not be sufficiently severe to attract the patient's attention. The severity of the attacks increases with their frequency, and each attack usually leaves the eye in a worse condition. Such a premonitory stage may exist for a year, or even longer, but cases also occur in which there is no premonitory stage. (See Glaucoma fulminans.)

The onset of a true glaucomatous attack usually takes place at night, and is characterized by violent radiating pain, excessive lacrymation, and pericorneal injection; the cornea is steamy and anæsthetic, and the iris in consequence is discoloured; the anterior chamber of the eye is shallow and the pupil moderately dilated, and the reflex is of a greenish hue. The patient often complains of subjective sensations of light, called "light flashes," and vision is partly or completely lost. When the intra-ocular pressure rises it may be accompanied by vomiting and other functional disturbances which simulate bilious attacks and tend to deceive both patient and physician. Headache and ciliary neuralgia are also present in the early attacks. In some cases such an attack as has just been described may pass away in the course of two or three days, although it should be understood that there is not a complete remission of the symptoms. Some visual defect always remains, the pupil is sluggish, and the tension is still above the normal.

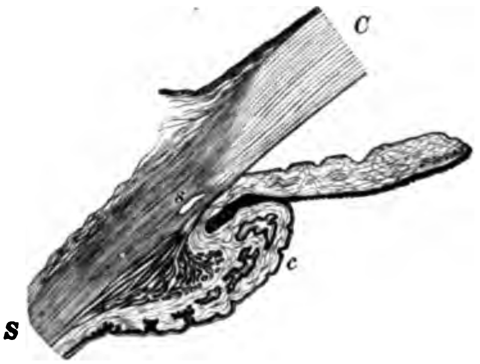

Fig. 139.—Iris and Ciliary Body in Recent Inflammatory Glaucoma. Magnified 9 × 1.

The ciliary process, *c*, is so greatly swollen that it pushes the root of the iris forward and presses it against the sclera, *S*, and the cornea, *C*. The sinus of the anterior chamber, which should lie somewhat behind Schlemm's canal, *s*, is thus closed. The ciliary muscle shows the pronounced development of the circular muscular fibres (Müller's portion), characteristic of the hypermetropic eye.

In the course of a few weeks or months there is a second similar attack, and this, too, may gradually pass away, although the eye is left in a worse condition than after the complete subsidence of the first attack. The succeeding attacks occur at shorter intervals, and if the eye is examined during a remission the vitreous and cornea are found to be clouded to a very considerable degree, the optic papilla cupped, and an arterial pulsation may readily be observed. In the later stages of the disease there is no remission of symptoms, the violent glaucomatous symptoms becoming permanent, and vision hopelessly destroyed. Contraction of the visual field, particularly at the nasal side, is present, and becomes more marked with each succeeding attack. Acute glaucoma in the majority of cases affects but one eye at a time, and is attended by swelling and œdema of the lids, congestion of the conjunctiva, prominence of the episcleral veins, and pericorneal injection.

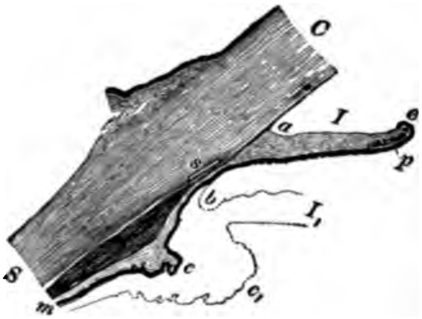

Fig. 140.—Iris and Ciliary Body in Old Inflammatory Glaucoma. Magnified 9 × 1.

The dotted line gives the outline of the iris, I_1, and the ciliary body, c_1, in the normal condition. The root of the iris is adherent to the sclera, *S*, and the cornea, *C*, wherever it has been pressed against them by the ciliary body. The attachment of the iris is hence displaced forward and lies in front of Schlemm's canal, *s*. So, too, the sinus of the anterior chamber is displaced from *b* to *a*. Wherever the iris has become adherent, it has been thinned through atrophy, so that in places—*b*, for example—it consists of scarcely anything more than the pigment layer. Even the free portion of the iris, *I*, appears in consequence of its atrophy narrower than the normal iris, I_1. Over the pupillary border, *e*, the retinal layer of pigment turns forward farther than usual, and the sphincter pupillæ, *p*, also shares to some extent in this eversion. The ciliary body, owing to its having become atrophic, has again separated from the iris, and in fact more so than in the normal condition, so that it is now removed from the iris by a broad interval. The atrophy affects both the ciliary muscle, *m*, and the ciliary process, *c*.

As the glaucomatous attacks increase in frequency the cornea becomes comparatively insensible to touch, showing less reaction when lightly touched than the normal eye.

Glaucoma is usually attended with pain, which is especially pronounced in those cases in which the intra-ocular tension is high. It is located in the eye, and also distributed over the branches of the fifth cranial nerve. It is difficult to alleviate this pain by local treatment, but if it is attempted, such drugs as eserine, which diminish the tension, should be employed.

High intra-ocular tension persists even after vision has been totally destroyed, and may cause atrophy of the iris, opacity of the lens, and ulceration of the cornea. The characteristic cupping of the disk common to all forms of glaucoma increases with the increase of tension.

Hæmorrhages into the anterior chamber of the eye are very apt to occur. Later there is staphylomatous bulging of the sclerotic in the ciliary region, or farther back; and, finally, such eyes may develop acute purulent chorioiditis, and the disease end in *phthisis bulbi.*

The terminal stage of acute glaucoma is known as *absolute glaucoma.* There is no sharp line separating this stage of the affection from those preceding it, but absolute blindness in addition to the other symptoms may be taken as an indication of its presence. The congestive phenomena are absent, with the exception perhaps of a zone of pericorneal injection or dilatation of the episcleral veins, and nothing remains to show the presence of the previous inflammatory condition. The insensibility and haziness of the cornea often persists. Vesicles may form on its surface that may become perforating ulcers. The pupil is dilated and immobile and is filled by a greenish reflex. The iris is shrunken and discoloured, and at the margin of the pupil on the iris will be found a border of dark pigment. The anterior chamber remains shallow and tension is increased. The pathological cupping of the disk becomes greater and atrophy of the optic nerve supervenes. The increased tension may also induce staphyloma of the sclera.

The increased tension, the weakening of the coats of the eye, the vascular disturbances, etc., all tend to impair the nutrition of the eye, so that after a while degeneration begins. This is manifested by the corneal ulcerations, staphylomata of the sclera, retinal detachment, lenticular opacities, various subjective phenomena of light, atrophy of the optic nerve, shrinking of the globe, etc. An eye undergoing degeneration after glaucoma is also liable to become the seat of irido-cyclitis or panophthalmitis as the result of corneal perforations from the most trivial forms of ulcers.

Glaucoma fulminans is a variety of acute inflammatory glaucoma that is characterized by an absence of premonitory symptoms or periods of remission. It occurs less frequently than the other varieties of glaucoma, and runs its course in a very short time. The onset of the affection is extremely acute, and the symptoms are more severe than in the ordinary acute form, and blindness may follow within a few hours.

Subacute glaucoma, while not a distinct variety of glaucoma, is applied to the attacks that precede or succeed an acute attack. It is characterized by exacerbations and remissions of less intensity than in acute glaucoma, but without complete relief at any time.

The symptoms are the same as in other primary forms of the affection, and it eventually terminates in acute or chronic glaucoma.

Chronic Glaucoma.—Glaucoma may begin as a chronic affection, or it may develop insidiously from the constant repetition of mild acute or subacute attacks. The premonitory attacks become more and more frequent and continue for a long period, and the intermissions are of shorter duration, until finally no intermissions are observed, and the disease gradually and almost imperceptibly assumes a chronic form. There is no pain in the eye at any time in this variety of the disease, and the patient may only become aware of its existence after vision has been greatly impaired or blindness has occurred.

Perhaps the first symptom that will attract the attention of the observer will be the marked failure of accommodation, necessitating the frequent changing of the presbyopic lenses. A careful examination of the exterior of the eye at this time will show increased intra-ocular tension, which progresses until stony hardness is reached, dilatation and tortuosity of the subconjunctival veins, haziness and lessened sensibility of the cornea, shallow anterior chamber, dilatation and impaired motility of the pupil, etc. Pain is absent. In addition to impairment of vision there will be found contraction of the visual field, most marked towards the nasal side.

Ophthalmoscopic examination reveals considerable cloudiness of the media, so that it is often impossible to distinguish the details of the eye-ground. In such cases the indirect method will be found extremely useful. The optic nerve presents the characteristic glaucomatous cup that is pathognomonic. This excavation of the nerve-head involves the entire disk, and has steep overhanging edges over which the blood-vessels bend sharply and are lost to view to reappear in the bottom of the depression. The depth of the cup may be ascertained by noting the difference between the refraction of the edges and that of the centre of the papilla. The retinal veins are widely dilated and tortuous, while the arteries are contracted and possess an abnormal pulsation peculiarly characteristic of this disease.

Non-inflammatory or Simple Glaucoma.—This affection was for a long time considered distinct from glaucoma, with which it was supposed to have nothing in common but the excavation of the optic nerve, and it was originally described by von Graefe under the title of "amaurosis with excavation of the optic nerve."

It is characterized by an entire absence of inflammatory phenomena or pain, and the diagnosis is made from the ophthalmoscopic appearance and the abnormal increase in the intra-ocular tension.

In the majority of cases the course of the affection is exceedingly slow and its gravity may fail to be recognised by the patient until well advanced by reason of its insidious onset. There is an entire want of prodromal symptoms, and the only complaint the patient makes is an inability to perform close work at a comfortable distance. This weakness of sight tends to increase, and reading, sewing, writing, etc., become impossible. This is confused by the laity with the normal failure of accommodation incident to advancing age, and the patients consult refracting opticians, with whom the true nature of the affection is equally vague. The convex lenses prescribed for the presbyopia under these circumstances fail to retard the progress of the disease and are of no value whatever.

Externally the eye may appear normal. The refracting media may be quite clear; the cornea may remain sensitive; the depth of the anterior chamber may be unaltered; and the iris may be normally or only slightly discoloured. Comparison with the unaffected eye is always necessary in these cases to detect minor differences. The pupil in some cases is dilated to a moderate degree and reacts rather sluggishly. The tension may or may not be elevated, but an increase is not constant. Examination of the fundus reveals the presence of the characteristic cupping of the disk and arterial pulsation. Examination of the visual field shows the usual contraction most marked towards the nasal side.

The affection is essentially chronic from the start, and at no time is there any inflammatory reaction. With the increase of tension the excavation of the papilla becomes deeper, and atrophic changes in the optic nerve, blood-vessels, and ocular tunics take place. The field of vision becomes contracted to a corresponding degree, and complete blindness supervenes as the atrophic process progresses.

The condition begins as a unilateral affection, but both eyes are frequently involved before the completion of its course.

Secondary glaucoma is that variety which is directly traceable to some other ocular condition.

Glaucoma occurs occasionally after hæmorrhage, and is characterized by symptoms similar to those of acute inflammatory glaucoma with the addition of the extravasation of blood into the media and tunics (hæmorrhagic glaucoma). The affection presents itself in from two to eight weeks after the retinal hæmorrhages, and tends towards absolute blindness in spite of the most prompt treatment.

Secondary glaucoma also occurs in connection with intraocular tumours, adhesions of the iris to the lens or cornea, injuries and luxation of the crystalline lens, etc. Elevation of tension may occur in a number of affections, but can only be considered glaucomatous when vision is impaired, the disk abnormally excavated, and the visual field is contracted coincidently. The termination of secondary glaucoma differs in no respect from that of primary glaucoma.

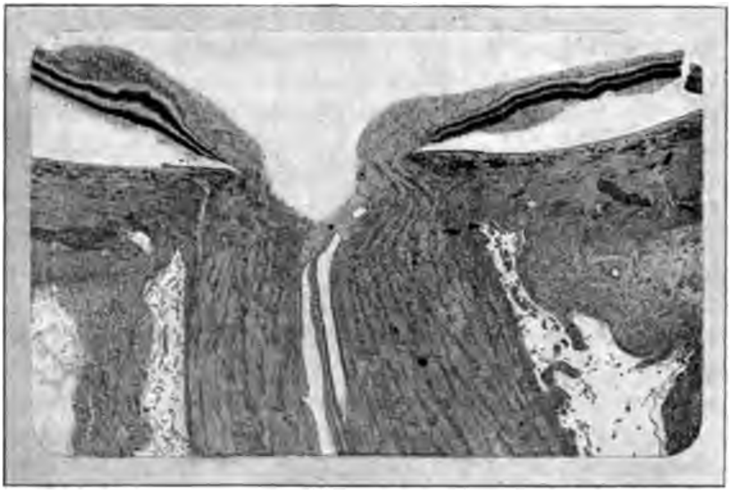

FIG. 141.—LONGITUDINAL SECTION OF NERVE SHOWING GLAUCOMATOUS CUP.

Diagnosis.—Glaucoma, on account of its various forms, is liable to be confused with a number of ocular affections, but a distinction can usually be made by noting the presence or absence of increased tension with pathological cupping of the nerve and arterial pulsation. Either of these symptoms may exist in connection with less serious affections, but their cômbination is pathognomonic of glaucoma.

It is therefore of great importance to ascertain the tension in all cases as a routine procedure, and this is best accomplished by palpation. The patient should be directed to look downward, and the index-fingers are lightly placed upon the closed lid immediately beneath the supra-orbital arch, the remaining fingers resting upon the forehead or temple. Pressure is then exerted alternately by the fingers and the tension estimated.

For convenience, T has been adopted as the symbol for normal intra-ocular tension. T + ? denotes a doubtful increase of tension; T + 1, T + 2, and T + 3 indicate the three varying degrees of hardness of the globe—T + 3 denoting stony hardness. The minus sign, with the same figures, indicates diminished pressure, T — 3, for example, indicating a perfectly flaccid condition of the globe.

Comparison with the unaffected eye is always necessary as well as with the normal eye. The method is only relatively accurate and requires considerable practice for precision in its results.

The pain and increase of tension in spasm of accommodation in connection with an unusually deep physiologic cupping of the optic disk may mislead the casual observer, particularly if the media are somewhat hazy and high errors of refraction are present. Such cases occur in comparatively young individuals, and are unassociated with any disease of the iris, lens, or retina. The vision improves with the proper correcting lens and the visual field remains unaltered.

Glaucoma may be mistaken for iritis, particularly if there is an increase of tension in the latter affection. In iritis, synechiæ may be demonstrated and the depth of the anterior chamber will remain normal. Ciliary injection and photophobia will be marked, and careful examination of the cornea by oblique illumination will show the presence of dotted opacities on the posterior layer of that structure. The history, age, course, and underlying cause will aid greatly in differentiating these conditions.

Conjunctivitis has been mistaken for acute glaucoma when the cornea has been involved at the same time. The tension may be elevated in conjunctivitis, but is not constant. The pupil is normal and the iris is unaffected. A clear view of the fundus will reveal an absence of the characteristic cup and arterial pulsation.

Cataract may be confused with glaucoma on account of the peculiar greenish reflex that fills the pupil, and by ancient writers these affections were considered but subdivisions or varieties of the same condition. Recourse to the candle-flame test of Sanson will show the presence or absence of lenticular opacities, while ophthalmoscopic examination of the fundus will reveal the presence or absence of the cupping of the optic nerve and the arterial pulsation.

The atrophy of the optic nerve common to the later stages of glaucoma may be taken for the original condition and cause of the visual impairment and contraction of the visual field. In optic atrophy there is no increase of tension, the fields are uniformly contracted and central vision is diminished to a greater extent. Pain and inflammatory symptoms are absent. The cupping in optic atrophy is more shallow and gradual than that in glaucoma. Colour-blindness and scotomata are more common in optic atrophy.

Presbyopia may be differentiated from the failure of accommodation found in glaucoma by the absence of such concomitant symptoms as contraction of the visual field, increased tension, dilated and sluggish pupils, cupping of the optic disk, etc. The failure of accommodation in glaucoma is not relieved by the wearing of convex lenses, as in presbyopia.

Glaucoma is attended by anæsthesia and cloudiness of the cornea in addition to the other characteristics previously mentioned, and this may serve to render the diagnosis easy in obscure cases. To determine the sensitiveness of the cornea the eye should be directed upward and outward or upward and inward so as to deflect the visual axis. The cornea is then touched with a small pledget of cotton or silk, and under normal conditions this irritation is sufficient to cause spasmodic closure of the lids.

The diagnosis of the different varieties of glaucoma is more difficult on account of the frequency with which these varieties run one into the other. Acute inflammatory glaucoma is always of rather short duration, and is attended by pain and other symptoms of acute inflammation. These characteristics will serve to distinguish it from chronic glaucoma, in which the onset is insidious, the course slow, and periodic exacerbations and remissions are frequent. Pain is not severe, and the inflammatory reaction is at no time intense. Subacute glaucoma possesses features common to both these forms, and is differentiated only by exclusion. Absolute glaucoma is frequently present when the patient presents himself to the ophthalmic surgeon, and its recognition is important on account of its prognostic significance. It is characterized by blindness in addition to the other symptoms of glaucoma with atrophic changes in the optic nerve, retina, sclera, iris, and lens. Inflammatory symptoms are absent in uncomplicated cases, and pain is usually absent. Hæmorrhagic glaucoma is easily distinguished from the other varieties by the retinal hæmorrhages that precede it and by its sudden onset and short course.

Secondary glaucoma is seldom difficult to diagnose on account of the prominence of the underlying conditions. The conditions already mentioned, which are liable to be complicated by secondary glaucoma, should always be carefully watched during their course, as an increase of tension is always suggestive of the onset of glaucoma. Frequently it is impossible to obtain a view of the fundus, and the increased tension, pain, etc., then become diagnostic.

Treatment.—The treatment of glaucoma may be conveniently divided into non-operative and operative.

The non-operative treatment is general and local. The constitutional measures recommended include rest, abundance of sleep, interdiction of close work, correction of any ametropia present, moderation in eating and drinking, regulation of the bowels, and the avoidance of any of the causes that have been considered as predisposing to the condition. The salicylates and iodides should be administered if there is any reason to suspect the presence of rheumatism or gout. Locally, the instillation of myotics, such as eserine and pilocarpine, have been found extremely valuable. Eserine sulphate is employed in solution in the strength of 1 grain to 3 drams, while pilocarpine hydrochlorate is used in the strength of ¼ to ½ grain to 2 drams of distilled water.

Normally, the instillation of myotics or mydriatics in the eye is productive of no appreciable alteration in tension, but if there is any pathological condition of the iris or anterior chamber their improper application is productive of disastrous results. The use of atropine in an eye predisposed to glaucoma by the presence of some obstruction in the angle of a shallow anterior chamber will increase the tension to a great degree and precipitate an attack of primary glaucoma, which may be aborted and the tension reduced to normal by the prompt instillation of eserine.

Myotics influence tension by drawing the iris, during the contraction of the pupil, away from the angle of the anterior chamber, and are of value only when the iris is in a perfectly healthy condition. They are useless when the sphincter muscle is paralyzed from pressure on the ciliary nerve, as in some acute cases of glaucoma, and when the iris is atrophic and adherent to the cornea or lens, as in cases of long duration. It can easily be seen from the foregoing that myotics find their greatest field of usefulness in the prodromal stages of glaucoma, and will aid greatly in cutting short the duration of the attack in the absence of structural changes in the iris. Unfortunately, the greater number of cases are seen when further developed, and myotics can be considered only as palliative measures.

In the employment of eserine considerable hyperæmia of the conjunctiva and ciliary congestion and pain are sometimes induced, so that strong solutions should not be used. The combination of cocaine with eserine is less disagreeable.

Morphine is often used in glaucoma to lessen the pain, and it must be remembered that its benefit is derived partly from its myotic action.

Operative treatment consists of iridectomy, paracentesis, sclerotomy, removal of the superior cervical ganglion of the sympathetic, enucleation, and resection of the optic nerve.

Iridectomy for the relief of glaucoma was first performed by von Graefe in 1856, and differs from the ordinary iridectomy in several respects. It has for its object the opening up of the filtration area at the angle of the anterior chamber. In order to accomplish this purpose it is necessary that the incision should be as far back in the sclerotic margin as possible, so that the ciliary body is uninjured and the keratome enters the anterior chamber, and that a wide portion of the iris should be removed.

In cases where the intra-ocular tension is + 1 or higher the operation should be performed under ether anæsthesia, but in cases in which the tension is lower cocaine may be used, but should be preceded by three or four instillations of eserine (gr. i to ʒiij) or until the pupil has become contracted to the size of a pin-point. The painful portion of the operation is the withdrawal and excision of the iris.

The instruments used in this operation are an eye speculum, fixation forceps, a large curved keratome, iris forceps, and De Wecker iris scissors. The ordinary Graefe cataract knife is preferred in this operation by some ophthalmic surgeons, but is a dangerous instrument in these cases. The incision should be made from above, as the coloboma of the iris is less disfiguring and less troublesome in this situation than when made below. The upper eyelid acts as a movable diaphragm in such cases and prevents the entrance of any excess of light. The conjunctiva is grasped at its inferior corneoscleral margin by fixation forceps and the eyeball is firmly held in any desired position. The eyeball is rolled downward as far as possible, and held there by means of the fixation forceps. The keratome is inserted 1½ lines behind the cornea and to one side of the vertical axis of the eye. The instrument is pushed into the anterior chamber until the point is opposite the lower margin of the pupil, after which it is withdrawn, making an outward and upward sweeping incision. The iris usually bulges out through this incision. The iris forceps, closed, are then inserted through the incision and advanced to the pupillary margin slightly to one side of the median line, where they are opened. A portion of the iris is grasped by closing them and carefully withdrawn through the scleral wound. As the iris is thus held up it is divided close to its base by three cuts by means of the De Wecker scissors, the lower blade of which is inserted beneath and within the edges of the corneal wound. The first cut is made by directing the point of the scissors towards the base of the iris, the second by having the point and blades parallel to the base, and the third by directing the point downward and outward from the base with which the heel of the scissors is in contact. The cutting should be performed entirely by the descent of the upper blade upon the lower blade, and the latter should remain stationary. The excision of the iris is greatly facilitated by gently drawing it in a direction opposite to that in which the incision is being made by the scissors, being careful to avoid tearing it. The object of the three incisions is to form a large keyhole pupil, which is a *sine qua non* for a successful result. It is very important to see that all the remaining portions of the iris are

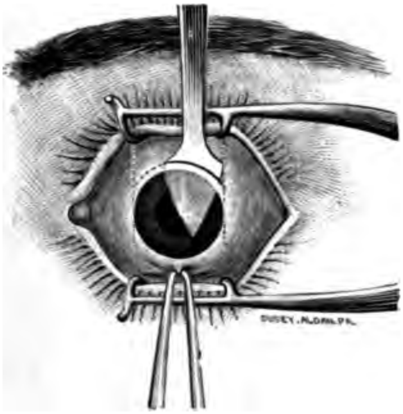

FIG. 142.—IRIDECTOMY FOR GLAUCOMA SHOWING THE MANNER IN WHICH THE KERATOME SHOULD BE INTRODUCED.

carefully replaced, and for this purpose a delicate tortoise-shell spatula may be used. A drop of weak atropine or homatropine solution may be dropped into the eye to insure wide dilatation of the iris. I have never experienced any untoward results follow, such as iritic adhesions, etc., in using these drops after this operation. Immediately after the operation the tension should fall, and the absence of such an occurrence is of unfavourable significance. A bandage should be worn until the anterior chamber reforms. This may be delayed for a week or more, or it may be preceded by an increase of tension. Occasionally after iridectomy the case may assume a malignant character, in which the lens is pushed forward and blocks the wound and the angle of the anterior chamber.

Paracentesis of the anterior chamber is occasionally employed in glaucoma as an emergency operation. It affords but temporary relief, the tension becoming again high as the fluid accumulates. It is of most value in glaucoma secondary to irido-cyclitis, and in those cases in which the anterior chamber is deep and its contents excessive.

Sclerotomy or incision through the sclera may also be performed in glaucoma, but is of less value than iridectomy. The scleral incision may be made in front of the iris (anterior sclerotomy) or behind the ciliary body (posterior sclerotomy).

Anterior sclerotomy is preferred in most cases. A Graefe knife should be entered about 1 millimetre external to the corneal margin and carried across the anterior chamber, emerging in the sclera at a corresponding distance from the corneal margin. These points should be on a line 2½ millimetres from the superior margin of the cornea.

The knife is then drawn back and forth with a sawing motion two or three times, after which it is slowly withdrawn, allowing the aqueous to escape before the flap has been completely cut, leaving a bridge of conjunctiva and sclera between the first and last cuts. The instillation of eserine before and after the operation will prevent any tendency towards prolapse of the iris. Cutting through the base of the iris, or the excision of a portion of it, is sometimes performed in addition. The benefit derived from sclerotomy may be due either to the formation of cicatricial tissue at the sclerocorneal margin that allows filtration of the ocular fluids through it, or to a fistulous condition following a cystic scar at the wound margins. Its results are never certain, and it is inferior to the operation of iridectomy.

Posterior sclerotomy consists in an incision of the sclerotic and vitreous 1 millimetre in depth by means of a Graefe knife. The conjunctiva is drawn to one side so as to cover the scleral wound at the conclusion of the operation. The knife is entered at a point 7 millimetres behind the corneal margin and between the external and inferior recti muscle, care being taken to avoid the ciliary body. As the instrument is withdrawn it is rotated slightly to allow gaping of the wound and escape of fluid. The result is only temporary, as the scleral wound heals within a short period and the tension again becomes high.

Excision of the superior ganglion of the cervical sympathetic has been shown by Jonnesco to reduce tension and induce marked contraction of the pupil. He also states that attacks of headache and other symptoms of irritative glaucoma are prevented, and that in the absence of trophic change vision improves. The ganglion may be reached by an incision over the anterior border of the sterno-mastoid muscle; the sheath of the carotid vessels should be either opened or pulled to one side and the ganglion will be exposed behind it, after which its excision may be easily accomplished by means of scissors. In addition to the results already mentioned, tachycardia, exophthalmos, and death have been reported as sequences.

Enucleation is advisable only when vision is completely lost and the eye is the seat of constant pain and irritation. It should be preceded by an iridectomy, as this operation sometimes postpones enucleation for a considerable period. Mules's operation is positively contra-indicated in this connection.

Neurectomy or resection of the optic nerve may also be employed in painful, blind, glaucomatous eyes. The operation is performed as follows: The lids are separated by means of the ordinary speculum and a vertical incision is made through the conjunctiva over the insertion of the external rectus muscle; the conjunctiva is then dissected off as far back as the external canthus will permit. This serves to completely expose the muscle. Two silk threads are then passed through it near its tendinous insertion. The muscle is afterward divided and drawn to the temporal side, thus exposing the globe. All tissue should be separated from the eyeball by curved scissors. A long strabismus hook, bent at a right angle, is then inserted along the globe until the nerve is found, after which it is brought forward by means of the hook. A duck-bill retractor is then passed downward until the nerve is encountered, when it is pressed down and out, keeping the adjacent tissues out of the way. A second bent hook is also passed backward and inserted under the optic nerve. A portion of the nerve is then exposed and severed by De Wecker's large curved scissors, which also controls the hæmorrhage of the central artery. The eyeball is then rotated forward and a small portion of its bulbar end is excised by means of scissors. The eyeball should be rotated into its proper place and the external muscle readjusted by the threads previously mentioned. The conjunctival wound is also closed by sutures, which may be removed in three days. Antiphlogistic dressings should be applied twice daily for several days, but usually there is very little reaction and no disfigurement.

Choice of Operations.—Iridectomy is indicated in acute glaucoma as soon as the diagnosis is made, as the progressive character of the affection influences the result to a considerable degree. It is productive of best results when performed in the premonitory period between the attacks. Myotics should be employed before and the second day after the operation. General anæsthesia is always necessary. In acute inflammatory glaucoma iridectomy causes rapid subsidence of the inflammatory symptoms, diminution of tension, and restoration of vision, all of which are usually permanent. Exceptionally, repetition of the operation is necessary, and still more rarely it produces no effect whatever upon acute inflammatory glaucoma.

In subacute glaucoma the employment of myotics is often productive of the desired results, and iridectomy or other operation is indefinitely postponed. Operative treatment, however, will be required sooner or later, and the sooner performed the better the result.

In chronic inflammatory glaucoma iridectomy serves to check the progress of the disease, lessening the tension, relieving the pain, and clearing the media, but fails to restore vision on account of the structural changes that have taken place in the eye. Sometimes there is a progressive loss of sight after the operation.

In simple glaucoma, although iridectomy is indicated, it is by no means followed by the favourable results as in acute inflammatory glaucoma. In about 50 per cent of cases arrest of the progress of the affection follows. In the remaining half the result may be temporary, a second operation may be necessary, or the affection may assume a malignant character.

Sclerotomy is indicated when for any reason iridectomy is impossible or when a relapse has followed iridectomy. It is used in preference to iridectomy by De Wecker and others in selected cases of simple glaucoma, infantile glaucoma, and hæmorrhagic glaucoma. It is also indicated when the iris is atrophic.

A combination of sclerotomy and iridectomy is sometimes necessary. A preliminary posterior scleral puncture is indicated when the anterior chamber is extremely shallow and the lens and iris are pressed forward to a considerable degree. Sclerotomy may be required after iridectomy when a portion of the iris is left behind and obstructs the filtration area, inducing a return of the glaucomatous symptoms.

Removal of the superior cervical ganglion of the sympathetic has not yet assumed its proper place in the treatment of glaucoma, and is still in the experimental stage.

In absolute glaucoma in which the patient experiences considerable pain, iridectomy should be performed, but it affords only temporary relief, and enucleation or resection of the optic nerve is required at a later period.

Prognosis.—Glaucoma is a serious disease, and never tends towards spontaneous cure, but progresses towards incurable blindness. Iridectomy is the best mode of treatment and the best results follow its performance in the early stages, in which cure is effected. In the later stages relief is produced which is more lasting than that produced by other methods of treatment.

In this connection Mendel's[1] report from Hirschberg's Ophthalmic Clinic will be of interest:

Two hundred and thirty-four cases of glaucoma have been treated in this clinic during the past seven years, and 258 eyes operated on for the disease. Of this number, 144 were women, 83 men, and 7 children. In 15 cases no operation was performed.

The best results were obtained by iridectomy in acute inflammatory glaucoma, complete or partial cure being effected in 82.2 per cent of the cases. The results in chronic inflammatory glaucoma, on the other hand, were not quite so good, only 71.1 per cent of the cases being cured. Iridectomy also proved of value in cases of simple hypertension, either improving sight, or at least preventing further injury. The results obtained from this series of cases, on the whole, confirm those obtained in 569 previous operations for glaucoma in this clinic.

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[1] The Ophthalmic Record, vol. xi, No. 4, April, 1902.

In Haab's recently published statistics the results are rather lower, partial or complete cures being effected in 77 per cent of the cases of acute inflammatory glaucoma, and 71 per cent in simple glaucoma. Under treatment with myotics 40 per cent of the cases were cured.

CHAPTER XV

SYMPATHETIC OPHTHALMIA

INFLAMMATION in one eye as the result of some sympathetic connection with a similar affection in the other eye. The eye that is the seat of the primary inflammation is known as the *exciting eye,* the other as the *sympathizing eye.*

Sympathetic ophthalmia consists essentially of a plastic cyclitis or an inflammation of the entire uveal tract. The cyclitis present in the exciting eye is usually traumatic in origin, but may arise from other causes. The most frequent forms of injury that may induce it are *wounds of the ciliary body* incident to the entrance of a foreign body into the eye and wounds of the corneosclera zone into which the iris and ciliary body have become prolapsed and incarcerated. It may also follow perforation of the cornea as the result of certain forms of ulcers. Pressure of long duration upon the ciliary body, such as results from calcareous formations between the retina and chorioid, tumours within the eye, dislocation of the lens, and bands of lymph the result of lens extraction or similar operation, may induce it. The pressure of an improperly fitted artificial eye upon a stump in which some of the ciliary nerves are embedded is also said to be a cause. The exciting factor is, in all probability, micro-organisms introduced into the exciting eye.

Other inflammatory conditions of the eye have been said to be sympathetic in character in certain cases, but are less frequent than the plastic cyclitis following disease or injury of the ciliary body in the exciting eye. The most common of these are serous iritis, irido-keratitis, chorio-retinitis, spasm of the orbicularis muscle, and optic atrophy. The period requisite for the development of sympathetic disease after the receipt of the injury varies from sixteen days to forty years, but usually the affection manifests itself in from four to eight weeks. Children and young adults seem to be more susceptible to this condition than older persons, but this is probably due to the fact that they are more exposed to its causes than others.

The onset of the affection is marked by such prodromes as photophobia, asthenopia, lacrymation, and tiring of accommodation, rendering near work irksome and distressing; contraction of the visual fields, various colour sensations, blepharospasm, photopsia, and cloudiness of vision. Pericorneal and ciliary injection, pain and tenderness in the ciliary region, and neuralgia along the course of the fifth nerve are also present. This stage of the disease is known as *sympathetic irritation* and is attended by no structural changes.

The removal of the cause of the disturbance gives rise to prompt subsidence of the symptoms, but its persistence induces true sympathetic inflammation. There is a rapid increase in the pain, which is "shrinking" in character and is best elicited by pressure over the ciliary region, causing the patient to draw back in agony. The cloudiness of sight steadily progresses until vision is greatly reduced. The anterior chamber is deep and the iris is discoloured. Frequently its first manifestation is a serous iridocyclitis, and often a slight optic neuritis may be demonstrated in the early stages. Ciliary injection and tenderness are marked and the media become extremely hazy. Vitreous opacities are common. Oscillating movements of the pupil may be detected, and are said to indicate the evolution of *sympathetic irritation* into true *sympathetic inflammation*. A plastic exudate soon forms as the result of the intensity of the inflammation in the sympathizing eye with posterior synechia, occlusion of the pupil, and retraction of the base of the iris in consequence. At the beginning of the disease the intra-ocular tension is above normal, but later becomes diminished as the exudate shrinks. Atrophy of the vitreous with prolapse of the retina, cataract, phthisis bulbi, and blindness follow at a later period.

These pathological changes do not always follow in rapid succession, except in marked cases; usually the various stages are separated by periods of apparent improvement, to be followed shortly by relapses, each relapse being a step nearer incurable blindness.

From a clinical standpoint, sympathetic inflammation is well understood, and the significance of its various phenomena is recognised by all ophthalmologists, but its morbid physiology is the subject of considerable discussion. Mackenzie believed that the inflammation travelled along the optic nerve to the chiasm, and from thence to the optic nerve and eye of the other side. The ability to produce sympathetic disease in eyes the subjects of optic atrophy seems to disprove this theory. Deutschmann assumed that the inflammation followed the lymph-channels surrounding the optic nerve to the chiasm, and from thence down the channels surrounding the optic nerve of the opposite side. It has also been suggested that the inflammation spreads along the ciliary nerves, and by their innumerable ramifications is transmitted to the ciliary nerves of the opposite side. The influence of the ciliary nerves in the production of the disease is undoubted, as it seldom arises in the absence of injury or disease of the ciliary body. The manner in which they accomplish such results, however, has not been satisfactorily demonstrated.

The recent advances in bacteriology seem to confute these theories, as it has been shown that all diseases are due to the effect of micro-organisms proliferating upon suitable soil. Consequently this disease is not an exception, and is produced by pathogenic bacteria as yet undescribed. Their means of conduction to the sympathizing eye also lacks satisfactory explanation, but it is probable that they infect, by means of their toxines, the lymph-current traversing the channel described in Deutschmann's theory. It is also held by some that the bacteria enter the general circulation, travelling through the entire body, but fail to encounter a suitable culture medium for their growth until the eye, afterward known as the *sympathizing eye*, is reached. In the latter theory it would not be difficult to precipitate a general pyæmia if the health of the patient were below par in any respect.

Treatment.—As there are two organs in different stages of a malignant inflammation depending upon some connection existing between them, it has been advised to sever this connection by enucleation of the first eye affected or by cutting the ciliary nerves. This allows the eye known as the *sympathizing eye* to easily resist and overcome the morbid processes about to develop in it. Prior to either of these procedures attempts should be made to locate any foreign body in the eye by the X-ray or other means, and, if possible, to remove it, especially if the eye is injured by a fragment of steel, etc. If the foreign body is successfully removed the ocular condition should be carefully watched for twenty-four hours. If the efforts to remove it are fruitless either of the two operations just decided should be considered. Cutting the ciliary nerves by the method of Snellen (severing them posteriorly before entering the eyeball) is theoretically applicable, but clinical experience fails to demonstrate its efficacy in checking the progress of the disease. Enucleation is the most valuable operation in that it offers the greatest hope for cure, but before its performance is decided upon the relative condition of the two eyes should be carefully considered. Not infrequently, by delay, often unavoidable, the disease has so far progressed in the *sympathizing eye* that it is of less value as a visual organ than the *exciting eye.*

This emphasizes the necessity of prompt treatment in such cases, and as a guide to treatment the following rules will be found extremely useful:

1. Complete blindness with pain and sensitiveness to pressure in the *exciting eye* indicates its removal at once, particularly if the patient resides some distance from the hospital or an ophthalmic surgeon. In case of refusal upon the part of the patient, he should be warned of the consequences and instructed to return at once if the symptoms persist and tend to progress. In eyes blind as the result of destructive inflammation at some time previous, and which are quiet in every respect, the patient should be warned of the probability of sympathetic inflammation and instructed to seek skilled aid at the first symptom of irritation in either eye.

2. The presence of a foreign body that has resisted attempts at its removal in an eye painful and extremely sensitive to pressure indicates removal of that eye even if vision is comparatively good, as blindness is inevitable as the result of the purulent inflammation which nearly always follows. Encapsulation of a foreign body is extremely rare.

3. The occurrence of injury or a perforating wound of the ciliary body with marked diminution of vision is always followed by cyclitis, and the close relation between this disease and sympathetic inflammation demands enucleation of the injured eye in such cases.

4. The appearance of the irritative stage of sympathetic inflammation in an injured eye calls for removal of the *exciting eye* at once. If the exciting eye possesses good vision and is comparatively quiet the expectant treatment should be followed up for a short period; meanwhile the degree of diminution in visual acuity

in each eye should be compared at frequent intervals. A further loss of vision indicates immediate removal of the exciting eye.

5. In cases in which the patient is seen during the height of the sympathetic disease it is perhaps best to wait for a subsidence of the inflammation to determine which is the better eye as regards visual acuity, as sometimes the *exciting eye* retains the most vision. The application of hot compresses and the instillation of cocaine with atropine will serve to lessen the pain to some extent, but usually morphine is necessary. Subconjunctival injections of corrosive sublimate and normal salt solution have been recommended highly in this condition.

6. An injured eye with good vision and the absence of any inflammatory symptoms contra-indicates immediate enucleation.

In all cases the patient should be placed at absolute rest in bed in a darkened room, leeches should then be applied to the temple, and mercurial inunctions freely employed. The administration of quinine and the salicylates to the point of tolerance is beneficial. Relaxation of accommodation by the instillation of atropine should never be neglected, as occasionally sympathetic irritation is simulated by a partial spasm of accommodation.

Evisceration or amputation of the anterior segment of the globe through the ciliary region has been performed with success in a number of instances. It should be followed by a thorough curetting of the contents of the eye, leaving the sclera only intact. Antiseptic douches should be freely employed to irrigate the cavity remaining. This operation may be further modified by the insertion of a gold ball into the sclera (Mules), which is united over it by sutures. The conjunctiva is also brought together in like manner. A conformer is placed over the globe to maintain it in position until healing is complete, usually three days. The only objection to this procedure is the possibility of pathogenic bacteria lurking in some fold within the sclera. This is of no moment in clean cases or when the sclera is left open, as it is then in the condition of an incised abscess, but when closed this possibility should be always borne in mind, as a return of purulent inflammation may be thus caused. It has also been advised to treat an eye the subject of purulent inflammation as an abscess, bisecting it anteriorly and allowing free drainage of its purulent contents.

It is always best to remove promptly an eye suffering from panophthalmitis, as no serious complications will follow. The free-drainage method *is not advisable.*

To determine whether the operation upon the *exciting eye* will be of value to the *sympathizing eye,* careful and repeated examinations should be made of the uninjured eye as regards vision, tension, ophthalmoscopical appearances, etc., as the presence of a plastic exudate is of unfavorable prognostic significance.

After the subsidence of true sympathetic inflammation various operations will suggest themselves for the improvement of the optical condition, but under no consideration, except possibly increased tension, should they be undertaken until twelve or eighteen months have elapsed and perfect "quiet" is established. An increase of tension to a marked degree may be relieved by repeated corneal puncture or possibly an iridectomy.

An artificial eye may be worn after the tissues in the orbit have completely healed and contracted. It should not irritate the stump in any way and should produce no discomfort.

The refraction should be examined frequently, and when the error has been found to be stationary, the correction should be ordered and worn constantly.

The *prognosis* is always grave. The most encouragement is offered by early enucleation of the *exciting eye,* but even then it is difficult to say with certainty that the *sympathetic irritation* has not already passed over into *sympathetic inflammation.* Time and subsequent events alone demonstrate the wisdom of operation in selected cases.

CHAPTER XVI

ROENTGEN RAYS IN DETECTING AND LOCATING FOREIGN BODIES IN THE EYE

THE value of X-rays in detecting and locating foreign bodies in the eye cannot be too highly estimated. It is frequently impossible accurately to locate a foreign body in the eye by simple inspection, or by an ophthalmoscopic examination. The foreign body may penetrate the eye with such force that it is driven completely through the eyeball, or it may lodge near the point of entrance, or in the interior of the fundus at a remote point, and yet not be located with the means usually at the disposal of the ophthalmic surgeon. The hæmorrhage immediately following the entrance of a foreign body, the rapid change in a punctured lens, or the escape of vitreous, all assist in obscuring the media through which the interior of the eyeball may, under normal conditions, be inspected.

The laboratory experiments that have been made since skiagraphs were first produced have resulted in making this a positive method of diagnosis, and metallic particles may now be accurately located. The work of Van Duyse, Lewkowitch, Hansell, Ring, and Stern have been most valuable in gradually perfecting this method of locating foreign bodies until it is now of great practical value.

Dr. Sweet,[1] of Philadelphia, devised a most ingenious locating apparatus. This apparatus "is fastened to the patient's head and carries two steel rods, each with a ball at the end. These balls are placed at a certain distance from the eyeball, one pointing to the centre of the cornea and the other to the external canthus, both parallel to the visual line and perpendicular to the plate. The skiagraphic plate shows the approximate position of the foreign body."

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[1] The Phila. Med. Jour., October 14, 1899.

McKenzie Davidson also designed a method which is simpler and less expensive than that in use by Sweet. He describes it as follows:

"A loop of lead wire is fixed by sticking-plaster to the edge of the lower lid, opposite a known point of the eye; the point of this wire, projecting upward, forms the landmark from which the position of the foreign body is calculated. The patient is directed to gaze steadily at a distant object in an axis parallel with the plate—that is, straight in front—and two exposures are made on the same plate with the sliding bar." The foreign body is then localized from the resulting photographic records.[1]

Dr. A. B. Kibbee, of Seattle, one of the earliest pioneers in this field of investigation, did much good work by a geometrical triangulation method, which, however, is too difficult for practical use.

Having tried these various methods and experienced some difficulty in determining the exact position of foreign bodies in the human eye, the author devised a simple instrument which in his opinion does the work in a far more efficient and satisfactory manner than has heretofore been possible.[2]

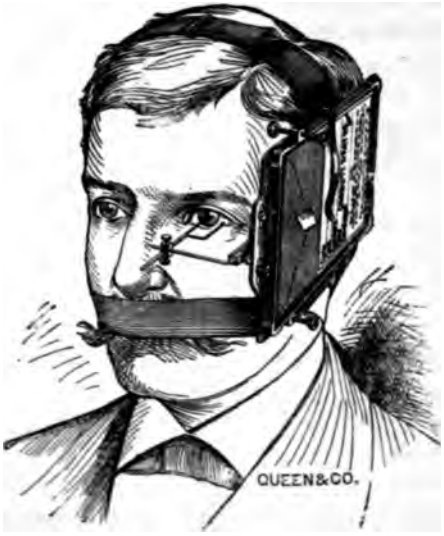

FIG. 143.—SWEET'S LOCALIZER.

As is well known, the location of foreign bodies by means of the Roentgen rays is possible only when such bodies are either partially or completely opaque to the rays. If a photographic plate is placed in the path of the rays, the shadow of the opaque object is projected on the photographic plate, and its position is determined by means of the position of the body, as compared with the position of the shadow of recognised parts of the body by which it is surrounded.

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[1] The Roentgen Rays in Medical Work, Walsh, 1899, p. 115.

[2] Phila. Med. Jour., February, 1902.

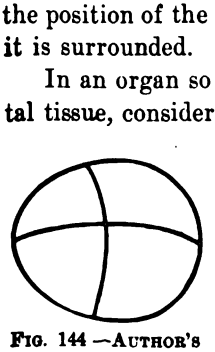

Fig. 144.—Author's Localizer.

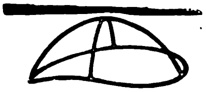

Fig. 145.—Author's Localizer.

In an organ so delicate as the eye, sunk as it is far in the orbital tissue, considerable difficulty has been experienced in determining the exact position of the foreign body by a finder or localizer, opaque to the Roentgen rays, placed outside of the eye. In order to minimize this difficulty the author has devised a localizer which comes directly in contact with the anterior half of the eye, and its geometrical shadow, thrown on the photographic plate, aids in locating a foreign body in the orbit or eyeball. This is especially so, since the outside rim of the localizer is formed of an opaque substance, so that, if care be taken, the position of the eye will be clearly determined by the geometrical shadow of the localizer. The apparent position of the foreign body will, of course, depend on its distance from the photographic plate, and it is absolutely necessary that the direction of the rays, and the position of the plate, be borne in mind when estimating the location of the body by means of the skiagraph.

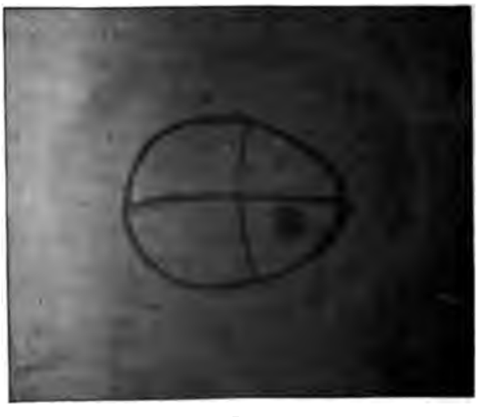

Fig. 146.—Author's Localizer in position showing Foreign Body. (Front View.)

The localizing device consists of an oval band of gold or silver, about 0.75 millimetre in width, so shaped as to conform to the outline of the eye. It is provided with two gold strands crossing in front at right angles, thus dividing the instrument into quadrants. This form of localizer has recently been improved.

The new form of the localizer differs but slightly; there are two nearly concentric bands or circles with cross-wires connected thereto, leaving a clear space for the cornea. Generally, however, the author has obtained the best results with the form shown in Figs. 144 and 145.

The latest modification of this instrument consists in substituting for the outer band one of smaller diameter. This device accomplishes the same localization with less shadow. The foreign body must be very minute to be eclipsed by the shadow made by this localizer.

When in use the localizer is adjusted directly to the surface of the eye to be examined, a solution of cocaine having been previously applied to the cornea and eyelids, thus permitting the instrument to remain in place long enough to make one or two skiagraphs without inconvenience to the patient.

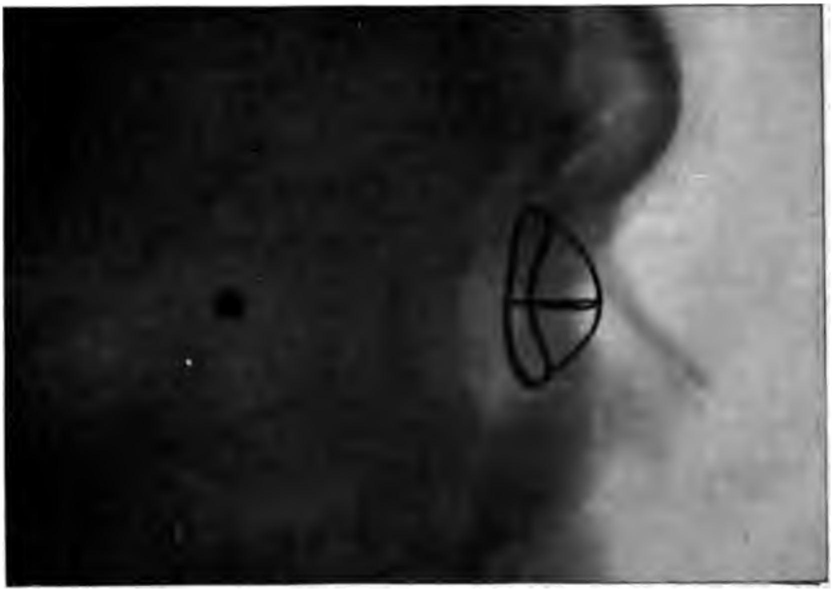

FIG. 147.—AUTHOR'S LOCALIZER IN POSITION SHOWING FOREIGN BODY. (Side View.)

The localizer adjusts itself to the eyeball, but does not prevent the eye to which it is attached from rotating or following the other eye. In order to bring the crossed wires directly over the centre of the cornea of the eye to be photographed, it is necessary to direct the other eye to a fixed point. The photographic plate being adjusted on the side of the temple nearer the injured eye, the Crookes's tube is then adjusted so that the Roentgen rays shall, as nearly as possible, fall perpendicularly on the surface of the photographic plate. If the foreign body lies within the shadow of the localizer, it must be in front of the equator of the eyeball; its distance behind the shadow of the instrument also determines its location, either in the posterior portion of the globe or orbit. A second occipito-frontal skiagraph at once identifies the quadrant in which the foreign body lies.

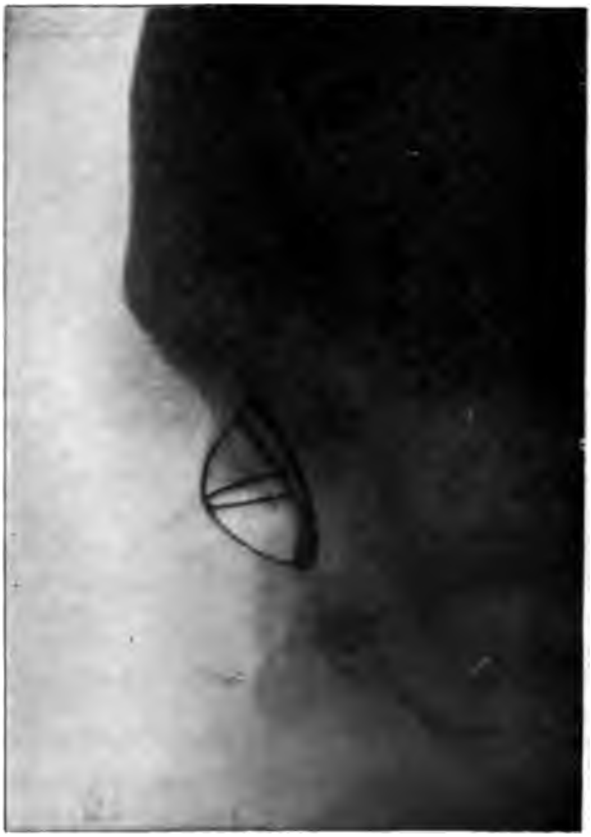

FIG. 148.—LOCALIZER SHOWING FOREIGN BODY IN THE EYE.

It will be noticed in the skiagraph shown herewith (Fig. 148) that some outlines of the localizer are sharper or clearer than others. In all cases the clearer outlines of the localizer indicate the position nearest the photographic plate. To a certain extent, therefore, the position of the foreign body can be judged by the sharpness of its shadow. Its absolute location may be verified by a second or control test. This test is made by placing a plate, not on the temporal side, but in front of the eye, and having the X-rays pass through the head. This second or occipito-frontal skiagraph is not so clearly outlined in its details as the first or temporal skiagraph, but with a little experience one can recognise any foreign body seen in the first test. The one defect in the method is that if the foreign body is very small and lies directly below the shadow of the localizer, it cannot be seen. In this case an additional temporal or occipito-frontal skiagraph must be taken with the source of the rays at a diverging angle, and no longer perpendicular, as in the first instance.

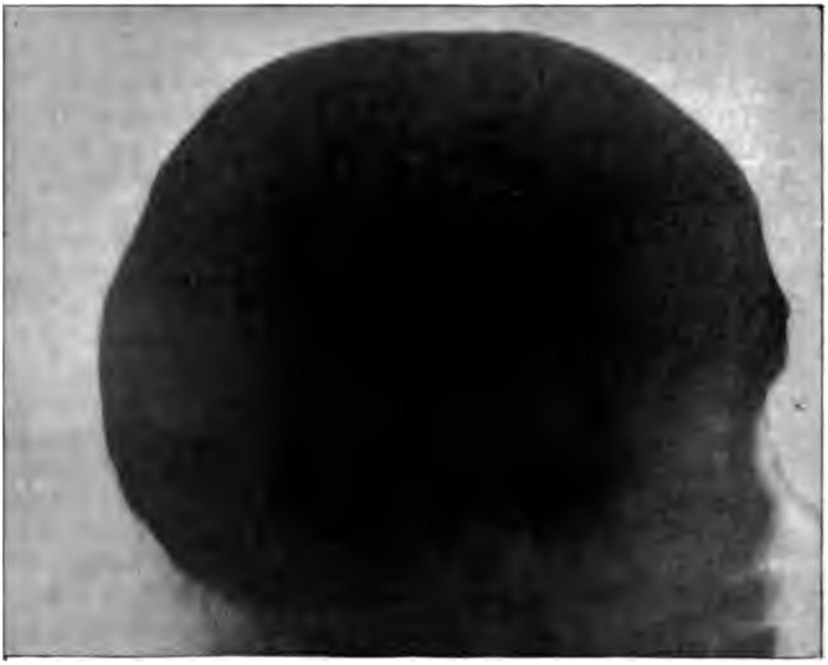

FIG. 149.—SKIAGRAPH SHOWING BULLET LOCATED IN THE SKULL BELOW AND BEHIND THE ORBIT.

Since taking his first skiagraph some five years ago, the author has succeeded in materially reducing the time of exposure. He thus eliminates an objectionable feature in the use of X-rays in ophthalmic work—namely, the danger of exciting conjunctivitis or dermatitis about the temple or the eyelids, and even of the inner tunics of the eye itself. In his ophthalmic work on living subjects the author obtains excellent temporal skiagraphs by an exposure of from five to ten seconds, while the occipito-frontal skiagraphs require about 2.5 minutes.

Regarding the technique of taking the radiographs the following report is given by Dr. Mihran K. Kassabian:[1]

A. *Temporal Skiagram.*

(1) Cocainize the injured eye, place the localizer in position by fitting it carefully under the eyelids, resting upon the cornea.

(2) Bandage a photographic plate (4 × 5 is a convenient size) on the temporal side of the injured eye.

(3) Seat patient on a chair, with his head supported by photographer's head rest, and direct him to look at a fixed point directly in front and on the same level with the uninjured eye.

(4) Place the Crookes's tube on uninjured temporal side, 15 to 18 inches from the sensitive plate, being careful that rays passing from the tube to the plate do so in a straight line through both eyes. A self-regulating tube with a 3-inch spark gap (hard tube), excited by a 15-inch coil, requires an exposure of ten to fifteen seconds.

During the past few years the exposure has been cut down from minutes to seconds.

A similar exposure, with a slight change of position of the tube, will confirm the first one and also will prevent the eclipse of a small body by the shadow of the localizer.

This bitemporal position will show the distance posterior to corner of the foreign body.

(B) *Occipito-Frontal Skiagram* will give the location of the foreign body in one of the *quadrants* into which the eye is divided by the *localizer.*

The patient is prepared the same as before, with the exception that the sensitive plate is bandaged in front of the injured eye, the tube being placed 8 to 10 inches from the occiput. After these two places have been developed and allowed to dry, they are placed at right angles; two imaginary perpendicular lines are then drawn from the two shadows upon the negatives, the point of intersections of those imaginary lines being the location of the foreign body in the eye.

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[1] In charge of the Roentgen-Ray Laboratory, Medico-Chirurgical Hospital.

The author has had very good results from this method, and believes it to be the most practicable yet devised. It is, of course, desirable to make as short an exposure as possible, and with the improved X-ray apparatus this is no longer a difficult matter.

CHAPTER XVII

DISEASES OF THE ORBIT

Introduction.—In order to clearly understand the pathological conditions occurring within the orbit, it is necessary to briefly reconsider its anatomical peculiarities. It is a bony cavity having the shape of a quadrilateral pyramid, its apex communicating directly with the cavity of the skull. It is surrounded by the nasal fossæ, the ethmoidal sinus, the sphenoidal sinus, the frontal sinus, and the antrum of Highmore. Contained within the orbit are the eyeball, ocular muscles, optic nerve, blood-vessels, nerves, and lacrymal gland, the interspaces of which are filled with fat and fascia.

The fascia of the orbit is of considerable importance on account of its numerous folds. One portion of it lines the orbit as the periosteum of its bony walls, while another is reflected anteriorly from the margin of the orbit to both tarsi, constituting the *sæptum orbitale.* Another layer surrounds the globe from the cornea to the posterior portion of the ball, forming an articular socket with the contiguous surface of the sclera, which is known as the capsule of Tenon. It is lined with endothelium and communicates directly with the supravaginal space of the external sheath of the optic nerve. The fascia is also prolonged over the ocular muscles as they pierce this capsule.

The blood-vessels of the orbit deserve attention, as they may be the starting-point of some of its morbid processes. The ophthalmic artery and its branches derived from the internal carotid artery supply the orbit with arterial blood. The venous blood is collected by corresponding veins and emptied into the ophthalmic, which joins the cavernous sinus.

The third, fourth, fifth, and sixth cranial nerves are found within the orbit in addition to the optic nerve. The third, fourth, and sixth are motor nerves, while the ophthalmic and superior maxillary branches of the fifth constitute the sensory nerves.

Along the course of the ophthalmic branch of the fifth nerve is the *lenticular* or *ciliary ganglion,* situated in the posterior portion of the orbit between the optic nerve and the external rectus muscle, and usually to the outer side of the ophthalmic artery. It receives motor fibres from the third nerve and sympathetic filaments from the carotid plexus. Its branches of distribution are the short ciliary nerves.

There are no lymphatic glands or lymph-vessels within the orbit.

All affections of the orbit are characterized either by an increase or decrease in the size of its contents or walls. With an increase in the size of the orbital contents or an encroachment upon the cavity by enlargement of its walls, the eyeball protrudes, *exophthalmos.* When the opposite conditions supervene the eyeball recedes into the orbit, and is known as *enophthalmos.*

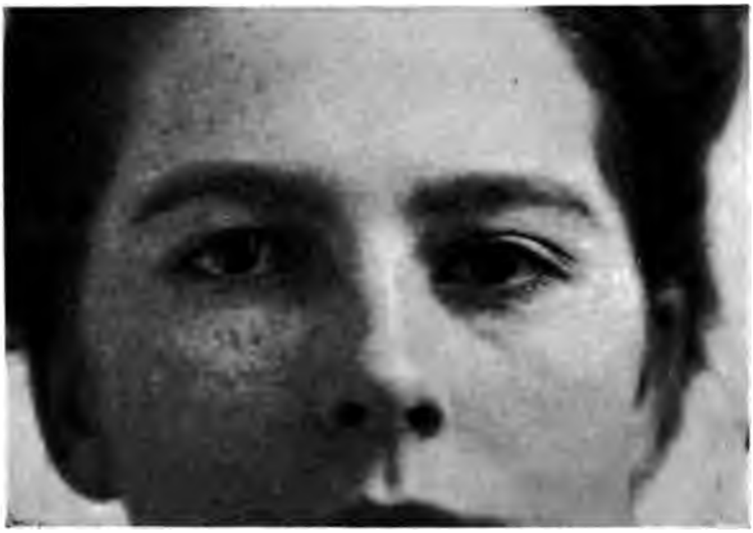

FIG. 150.—ASYMMETRY OF FACE—RIGHT EYE FOUR LINES ABOVE HORIZONTAL PLANE. ORTHOPHORIA.

In all forms of orbital disease there are certain common symptoms. Owing to the frequency of affections which encroach upon the orbital cavity either from within or without, exophthalmos is very common. Diplopia is present and ocular movements are more or less limited; occasionally their range is increased. Pain is rather frequent and tenderness may be elicited if inflammation is present. There is always more or less congestion and inflammation of the conjunctiva.

Congenital Malformations.—Very rarely the orbits fuse during fœtal life, so that only one orbit and one eye are present at birth, situated at the root of the nose. Such a condition is termed *cyclopia,* and is attended by other abnormalities of the head and brain. More frequently the eyeball is the seat of congenital malformations, thereby altering the contents of the orbit and interfering greatly with its subsequent development. A congenital absence of the eye, or *anophthalmos,* is usually bilateral, and is believed to result from a failure of development of the primary or secondary optic vesicle. It is often incomplete, and the eyeball is represented by a cyst of the lower lid within which may be found a rudimentary globe. A condition somewhat allied to this is the marked diminution of all the diameters of a completely developed eye, which is designated *microphthalmos.* The opposite condition of overdevelopment is termed *macrophthalmos,* and is attended by glaucoma and keratoglobus. The affection known as buphthalmos may be mentioned as a good example. The effect such congenital conditions of the globe have upon the development of the globe is obvious, and it must be remembered that a somewhat analogous condition is produced by enucleation of an eyeball in very young children; the resulting imperfect development of the corresponding orbit inducing marked facial asymmetry.

INFLAMMATION OF THE ORBIT

Periostitis of the orbit is sometimes observed, and it may be acute or chronic, localized or diffused. It may occur alone or combined with orbital cellulitis. As in periostitis elsewhere, it may terminate in thickening, suppuration, or caries and necrosis.

Prominent among its causes may be mentioned injuries to the orbit, received accidentally or through careless surgery, syphilis, tuberculosis, rheumatism, and extension from adjacent structures.

The symptoms vary considerably, according to the nature and course of the affection. In the most common form which attacks the orbital margin, there is present pain, tenderness upon pressure, hard immovable swelling, exophthalmos, and congestion of the conjunctiva and lids.

The exudate thus formed may be retained, absorbed, or thrown off. If retained, there is periosteal thickening; if absorbed, there is restitution to normal; if thrown off, there is suppuration, caries, and subsequent fistula formation. In the diffuse variety of periostitis all these symptoms are intensified, and, in addition, fever, headache, anorexia, constipation, delirium, and stupor are liable to supervene at any time. The pus may be discharged anteriorly or posteriorly, the latter being always followed by meningitis or cerebral abscess. Chronic periostitis is nearly always of syphilitic origin, and is attended by deep-seated nocturnal pains, thickening, and exophthalmos. Gumma of the periosteum may occur, in which case the swelling is distinctly localized.

Treatment.—In all cases the iodides, salicylates, and mercurials should be administered freely. Locally in acute cases hot compresses should be applied frequently, and early incision is indicated in order to relieve the tension of this very dense structure.

The *prognosis* in localized types is very favourable under prompt treatment, but its possible terminations should always be borne in mind. Chronic periostitis may last indefinitely. Syphilitic cases present the most favourable outlook.

Caries and Necrosis.—The altered nutrition of the bones of the orbit induced by the periostitis leads to death of the bone in particles. In the discharge of these particles suppuration is an accompaniment. A fistula is always present, the opening of which is surrounded by granulations. This fistula persists until the discharge of the carious particles is complete. The condition is most common in children as the result of syphilis and tuberculosis. Necrosis is observed with greater frequency in adults. It usually selects the margin of the orbit.

Treatment.—Internally, cod-liver oil, hypophosphites, syrup of the iodide of iron, and similar tonics combined with good food, fresh air, abundance of sunshine, etc., are of great value. Locally, antiseptic solutions should be used to cleanse the fistulous tract, and the carious material should be removed as soon as it has been cast off.

Drainage should be employed, and in persistent cases scraping of the bone may be necessary.

Cellulitis, or inflammation of the cellular tissue of the orbit, is an acute affection which almost invariably terminates in suppuration.

It arises from injury, local infection from surgical operations, and general infection through the blood, as in pyæmia, septicæmia, etc., extension of inflammation from adjacent structures, erysipelas, etc. It occasionally occurs without any assignable cause.

Symptoms.—The affection is manifested by chills, fever, anorexia, and other constitutional phenomena incident to suppuration anywhere in the body. Locally, the eye is protruded, the lids are swollen, and the conjunctiva chemosed. There is violent pain in the orbit and side of the head, which is increased upon pressure and upon any attempt to move the eye. Pus usually makes its appearance at the end of a week, and may discharge spontaneously into the fornix through the lids. Fluctuation may be obtained, particularly at the inner portion of the supra-orbital ridge. Vision is unaltered unless there is a coincident optic neuritis, a not infrequent complication. Thrombosis of the retinal vessels, panophthalmitis, and extension to the brain may be mentioned as occasional complications.

Diagnosis.—Orbital cellulitis is usually very easily recognised, but occasionally it is simulated in part by thrombosis of the cavernous sinus. In this latter affection there is present exophthalmos, œdema of the lids, chemosis of the conjunctiva, and lessened corneal sensations, together with rigours, high fever, nausea, vomiting, constipation, etc. The distinction between the two conditions may be made by the third nerve palsy, congestion of the papilla, and the presence of infective inflammation in one of the cavities of the skull in thrombosis.

Treatment.—Constitutional treatment should be maintained from the beginning of the affection. Purgation with the administration of small doses of mercury seems to have a decided antiphlogistic effect. Iron, quinine, strychnine, alcohol, etc., should also be administered. Morphine may be required to relieve the pain. Locally, hot fomentations of poppy-heads are of great benefit, together with leeching of the temple. Early and deep, single or multiple incisions either through the skin of the lids or conjunctiva are indicated upon the slightest suspicion of suppuration. Subsequent antiseptic irrigation aids the progress towards cure materially.

The *prognosis* is favourable in mild cases, and less favourable as the severity of the affection increases. Blindness may follow from optic neuritis, retinal hæmorrhage, or corneal suppuration.

The eyeball may be lost through panophthalmitis; or death may be induced by cerebral involvement. It is always a serious affection.

Tenonitis.—Inflammation of Tenon's capsule is a very rare orbital condition, and when present it is serous in character.

The affection may follow tenotomy or enucleation. Rheumatism, exposure to cold, and other constitutional disturbances may induce it. Occasionally it arises without any apparent cause.

It is manifested by exophthalmos, limitation of ocular movements, pain in the eye, particularly on motion, chemosis of the conjunctiva, and swelling of the upper lid. The duration is about three weeks. The diagnosis is made by exclusion.

Panophthalmitis.—Inflammation of the entire eyeball. This affection is really an acute purulent uveitis, but is considered in this connection to complete the inflammations of the orbital contents.

Causes.—It always arises from infection of the eyeball either accidentally or as the result of operations. The entrance of foreign bodies is a very frequent cause. Perforation of infected corneal ulcers is also an important etiologic factor. The infection may take place through the blood, as in the cases occurring in the course of septicæmia, pyæmia, cerebrospinal meningitis, and other infectious fevers.

Symptoms.—Owing to the early stages of this affection being localized to the uveal tract, the symptoms of purulent iritis, cyclitis, and chorioiditis are particularly prominent. The lids are swollen and the conjunctiva is congested and chemosed. Pain of varying intensity is present. Intra-ocular tension is greatly increased. There is rapid failure of vision, owing to the cloudiness of the cornea and the purulent exudate in the aqueous and vitreous, and it becomes impossible to view the fundus. All the structures of the eyeball become rapidly infiltrated with pus, ending in its total destruction.

The inflammatory process extends to Tenon's capsule and cellular tissue of the orbit, producing exophthalmos, and greatly limits the ocular movements. Rupture of the eyeball occurs in most cases, after which there is a subsidence of the symptoms. Later shrinking takes place, constituting the condition known as ***phthisis bulbi***.

Treatment.—The administration of tonics should never be neglected in this condition, as they aid in resisting any extension of the inflammatory process. Mercury is also of value for its antiphlogistic effect, particularly when combined with saline purgatives. The pain is sometimes very intense and requires hypodermic injections of morphine for its relief. Locally the application of hot moist compresses is also of value and should not be forgotten. Enucleation of the eye is always required sooner or later. Some authorities do not advise removal of the eye until the acute inflammation has subsided, fearing lest purulent meningitis should supervene. Deep scleral incisions are substituted for enucleation in order to evacuate the pus. Evisceration is also employed.

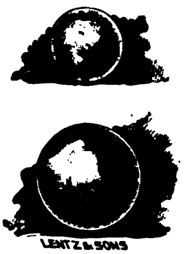

FIG. 151.—GOLD BALLS USED IN IMPLANTATION OPERATION.

Enucleation.—The operation of removal of the eyeball is not only employed in panophthalmitis, but also in eyes blind as the result of traumatism, irido-cyclitis, and glaucoma. Malignant tumours, sympathetic ophthalmia, and the presence of foreign bodies in the eye, particularly in the ciliary region, are additional indications.

FIG. 152.—INSTRUMENT FOR INTRODUCING GOLD BALL. (Carter.)

General anæsthesia is always to be induced for this operation unless especially contra-indicated. The eye-speculum is introduced and the eye is irrigated by means of some antiseptic solution. The conjunctiva is grasped close to the cornea and divided around the entire corneal margin. A pair of long, straight, thin, blunt-pointed scissors is then introduced with one blade beneath either of the lateral recti, which is divided close to its scleral insertion, leaving enough of its distal attachment for holding the eye by means of

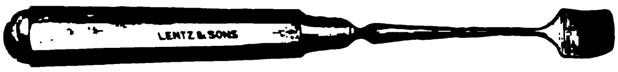

FIG. 153.—SCOOP USED IN MULES'S OPERATION AND IN GOLD BALL IMPLANTATION. (Carter.)

forceps. The scissors is then swept around the globe, severing each muscle with which it comes in contact in a similar manner. All other attachments to the globe are likewise severed by the scissors, care being taken to save as much of the orbital tissue as possible. A heavy pair of curved scissors is then passed along the eyeball, which may be forced out and the optic nerve divided, keeping the heel of the scissors close to the globe, so as to avoid "buttonholing" it. Rupture of the globe may occur during the operation, and renders it more difficult than under other circumstances. In such cases the tunics of the eyeball should be grasped by fixation forceps and dissected from its attachments by means of scissors. In staphylomatous eyes it may be necessary to employ a strabismus hook to bring the muscles into view, but ordinarily this procedure may be dispensed with to advantage.

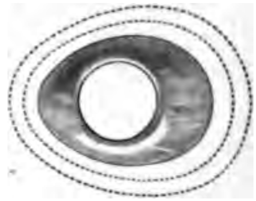

FIG. 154.—METALLIC CONFORMER.

After the eyeball has been removed hæmorrhage should be controlled by firm but gentle pressure, using a sterilized sponge over the eyelids, pressing them inward until the bleeding stops.

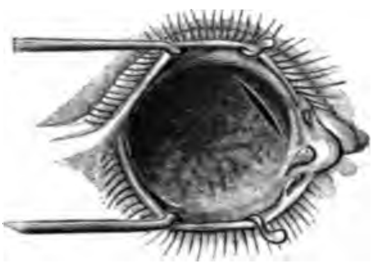

FIG. 155.—ORBITAL TISSUES BEFORE INSERTION OF GOLD BALL.

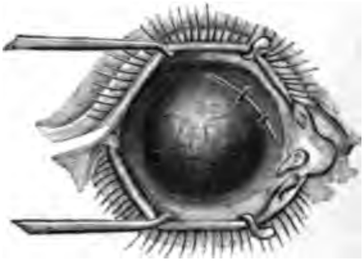

FIG. 156.—INSERTION OF GOLD BALL IN ORBITAL TISSUES.

Implantation.—After the globe is removed a gold ball is placed within the cavity and the tissues brought together over it by means of sutures. All the tissues, conjunctiva, and Tenon's capsule should be included in these sutures, else remarkable complications will follow the extravasation of blood between the various layers of the remaining ocular contents. Four sizes of gold balls are employed, 11, 12, 13, and 14 millimetres in diameter, and are preferable to the glass balls formerly used, in that they are unbreakable and are unaffected by the tissue fluids. The removal of a number of glass balls from the eyes of patients recently has demonstrated that the surface polish is destroyed and the glass eroded by the action of the tissues and their fluids within a comparatively short period (two years). The ball is held in position by a metallic conformer, which is placed directly over it and inside of the lids. An antiseptic dusting powder is freely dusted over the line of sutures. This is retained for a period of two or three days. The sutures are removed on the third or fourth day.

The advantages of this operation are as follows: More of the orbital tissues are retained than by any other similar procedures, and by their union over a gold globe a movable stump is formed. The gold ball is aseptic and never breaks. It never ulcerates through unless the tissues overlying it are extremely thin, and this is rarely the case when the ball is introduced at the time of enucleation. An artificial eye may be worn with decided comfort after such an operation, and may be moved synchronously with the fellow eye. This may be further facilitated by glass eyes having a cup-shaped depression on their posterior surface, being held in contact with the gold ball by suction.[1]

Implantation after Remote Enucleation.—In orbits from which the globes have been removed for a more or less considerable period the technique of the operation is slightly modified. In operating upon such an orbit, right side, after separating the lids with a speculum, the conjunctiva is grasped up and in, above the inner canthus in order to draw out the tissues. A Beer's knife or curved keratome is passed through the tissues obliquely and well down into the orbit, making an opening large enough to allow the ball to be pushed in behind the conjunctiva and other orbital tissues (Fig. 155). The opening is so placed that on completion of the operation the wound edges will be to one side of the gold ball, and consequently will not be subjected to any pressure. The gold ball is thus prevented from breaking through the centre of the conjunctiva. Curved scissors are introduced into the opening and are used to separate the tissues from the fibrous bands which have formed in the orbit, thus making a large pouch or *cul-de-sac* into which the globe can be inserted. In performing the operation on the left orbit, the incision is made up and out above the external rectus muscle, and the dissection carried out as already described. The gold ball (Fig. 151) may be introduced by a special instrument (Fig. 152) or by the fingers, and is aided in its lodgment by the scoop (Fig. 153). The incision is closed by two sutures, and the ball is retained in place by a metal shell modeled after an artificial eye and termed a "conformer" (Fig. 154). The after-treatment is the same as in the preceding operation.

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[1] This new eye has been made for me by Wall & Ochs, of Philadelphia, and is a great improvement over the artificial eye in general use.

Evisceration (Mules).—This operation differs from the preceding in that the cornea and the entire contents of the eyeball are removed, leaving behind the sclera. The anterior portion of the eye is transfixed by a Beer's knife and a superior flap made of the cornea, the remaining corneal tissue being cut away by means of scissors. A sharp spoon or curette is then introduced and the entire contents of the eye are removed. The cavity should be freely irrigated by means of an antiseptic solution. The edges of the sclera should be drawn together or an artificial vitreous in the shape of a gold or glass ball should be inserted (Mules's operation). The formation of an artificial vitreous by means of paraffin

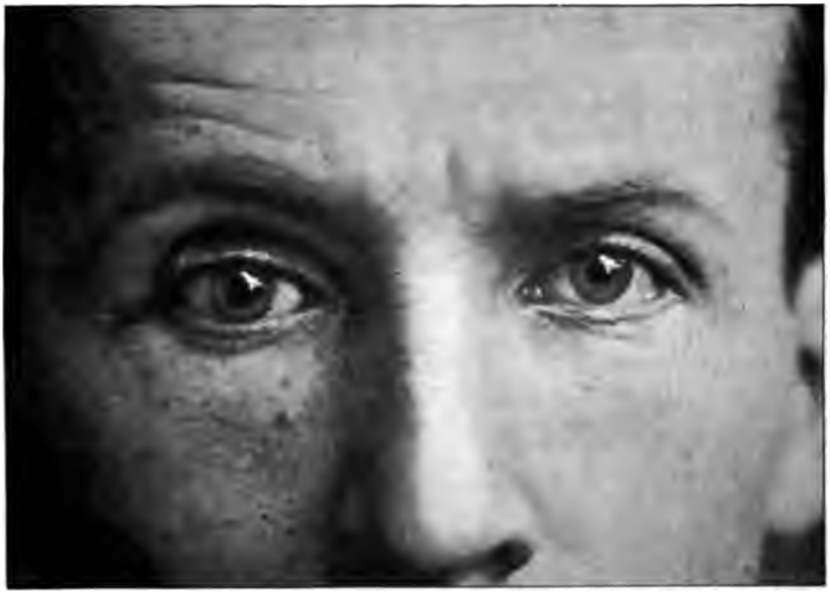

FIG. 157.—IMPLANTATION OF GOLD BALL IN RIGHT ORBIT, ARTIFICIAL EYE BEING WORN.

is by no means a commendable procedure. Evisceration was devised as a substitute for enucleation, to which it is decidedly inferior.

Prognosis of Panophthalmitis.—The prognosis of panophthalmitis is always unfavourable, as the inflammation destroys all the structures, and shrinking of the globe is a constant termination, rendering the eye completely blind and useless. It bears no relation to sympathetic ophthalmia.

INJURIES OF THE ORBIT

Under this heading may be included lacerations and contusions of the soft parts, fractures of the bony walls, and foreign bodies. Traumatism of the soft parts may result in hæmorrhage or contusion of the supra-orbital nerve. In hæmorrhage the extravasated blood may give rise to exophthalmos or it may induce optic atrophy by pressure on the nerve. Involvement of the supra-orbital nerve has been said to have induced amaurosis reflexly. Inflammatory reaction after wounds of the soft structures within the orbit may be intense, and suppuration and orbital abscess may develop. In fractures of the bony walls there is always injury to the adjacent soft structures, and injury to the nerves is not uncommon. The optic nerve may be directly or indirectly injured. Emphysema is a rather common accompaniment. Foreign bodies frequently enter the soft tissues of the orbit without involving the eye, and while there is always a possibility of the foreign substance penetrating the orbital wall and entering the brain, it is by no means rare to find very large substances lying encapsulated in the orbit without giving rise to any serious symptoms, and often without attracting attention.

Treatment.—All fragments of bone and foreign bodies should be carefully removed. Thorough cleansing is always necessary, and measures should be taken to prevent inflammation and its sequels. Antiphlogistic lotions should be freely applied at short intervals.

ORBITAL TUMOURS

Pulsating Exophthalmos.—Under ordinary circumstances exophthalmos is not attended by pulsation, but in arteriovenous aneurysm due to rupture of the internal carotid into the cavernous sinus following traumatism the eyeball and surrounding parts may protrude and pulsate. The patient complains of pain and peculiar noises in the head. Ptosis is also present. A distinct bruit may be heard over the eye and forehead, and the retina, conjunctiva, and eyelids are markedly congested. The cornea may be slightly cloudy and less sensitive than normal. The pupil is dilated and sluggish. Compression of the common carotid artery usually causes a disappearance of the pulsation and bruit.

According to Fick, it may follow an injury either direct, as a puncture through the orbit or a penetrating shot; or indirect, as a fracture at the base of the brain; or it may be due to arteriosclerosis or syphilis of the arterial walls which yield to some slight rise of blood-pressure, such as accompanies coughing.

Treatment.—The object of the treatment in these cases is to bring about thrombosis of the cavernous sinus. This may be greatly aided by rest in bed and restricted diet, reducing the liquids to a minimum. This procedure serves to lessen arterial pressure. Operative treatment consisting in compression or ligation, however, will be required. Electrolysis has been employed with gratifying results.

Prognosis.—It is impossible to forecast the termination of this condition with any degree of certainty. The exposure of the protruding eyeball nearly always results in some corneal complication. Vision may be greatly impaired by the anæmic condition of the retina or neuroretinitis. The occurrence of repeated hæmorrhages may threaten life. In the most favourable cases thrombosis of the cavernous sinus occurs, blocking up the wound in the arterial wall. About 7 per cent of cases recover without treatment.

Thrombosis of the Cavernous Sinus.—The occurrence of this condition is manifested by the following symptoms referable to the eye: proptosis, œdema of the eyelids, chemosis of the conjunctiva, haziness of the cornea with lessened sensation, partial or complete ocular paralysis, and sometimes inflammation of the optic nerve. It resembles orbital cellulitis in many respects and has been differentiated from it under *Diagnosis of Orbital Cellulitis.* This condition may be a termination of a pulsating exophthalmos or it may be infectious in origin.

In cases following pulsating exophthalmos no treatment is necessary; but in septic cases suppurative and antiphlogistic measures are indicated, as a fatal termination is the rule.

Simple Exophthalmos.—Protrusion of the eyeball without any pulsation. This symptom is common to all affections of the orbit, and particularly tumours. The orbital inflammations that may induce this condition have been considered in the beginning of this chapter. The association of exophthalmos with ocular paralysis and Graves's disease has also been described elsewhere. The remaining conditions that may induce exophthalmos are tumours of the eye, tumours of the adjacent orbital tissue, and disease of the adjacent sinuses. The ocular tumours include glioma, sarcoma, and epithelioma. The tumours affecting the orbital tissues consist largely of gumma, sarcoma, dermoid cysts, and vascular growths. The adjacent sinuses, the frontal, ethmoid, sphenoid, and the antrum of Highmore may be the seat of osteoma or osteosarcoma, or they may be attacked by chronic inflammatory conditions in which a mucocele is formed in the orbit. Tumours of the brain, lacrymal gland, and optic nerve may also encroach upon the orbit and induce exophthalmos.

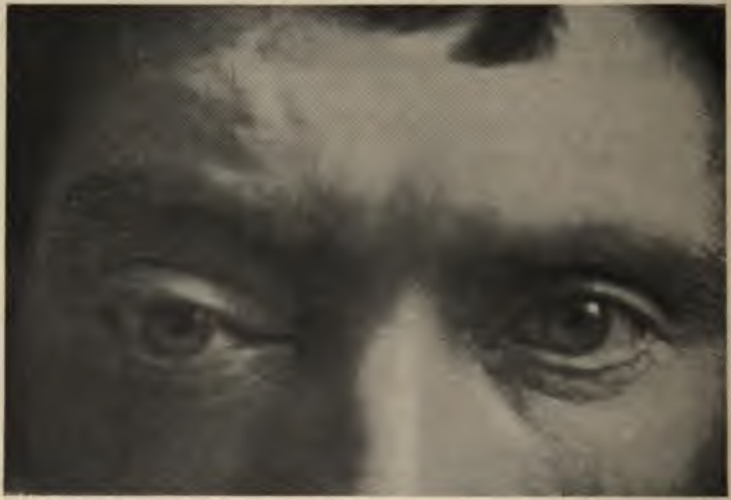

FIG. 158.—IVORY EXOSTOSIS OF RIGHT ORBIT; FIVE YEARS' DURATION WITH OPTIC ATROPHY. (Author's case.)

Orbital tumours, in addition to exophthalmos, are attended by a change in the direction of the eyeball, according to the size and location of the growth. There is also impairment of the motility of the eye, depending upon the location and pressure exerted by the enlargement. Vision is interfered with only when the nerve is pressed upon, inducing optic neuritis and subsequent atrophy. These tumours may be considered as benign and malignant; the former grow slowly and give very few symptoms, while the latter are particularly rapid in growth and occasion great pain. Among the benign tumours may be mentioned cysts, aneurysm, angioma, pulsating exophthalmos, distention of adjacent sinuses, etc. The malignant tumours are carcinoma and sarcoma.

The cellular tissue of the orbit is occasionally the seat of gumma, sarcoma, cysts, and vascular growths.

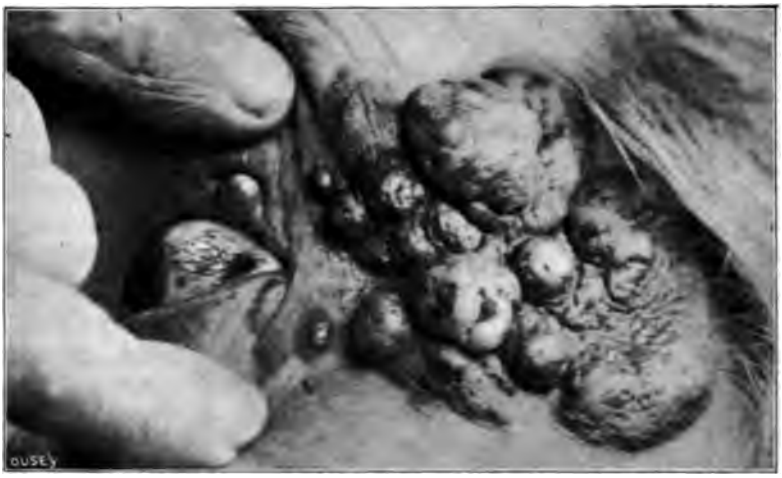

FIG. 159.—LARGE NÆVI OF THE FACE AND CONJUNCTIVA. (Author's case.)

Gumma in this region is most often encountered in the upper and inner portion of the orbit and is unilateral. The bony wall is coincidently involved. The duration is long, and the affection responds very slowly to treatment, which should be pushed from the start.

Sarcoma of the orbital cellular tissue has been described, but is extremely rare. Its growth is rapid and is attended by great pain. The treatment consists in evisceration or exenteration of the entire orbital contents. The X-ray treatment is now followed, but statistics as to results are meagre. A case of this character recently came under my observation in which the X-ray treatment was of very great service. The patient presented herself to me March 5, 1903, complaining of the enlargement of the left naso-orbital region of six weeks' duration. Proptosis was present to a slight degree. Tension was slight. Very little pain was experienced. Vision was $\frac{6}{6}$ in both eyes; the fields were not contracted, but there was diplopia when an attempt was made to perform near work. The diagnosis of malignant growth, probably sarcoma, was made. An exploratory incision was made April 17, 1903, by Dr. Gleason to confirm the diagnosis. Microscopic examination of a section of tissue taken from the growth by Dr. Harold G. Goldberg revealed the presence of sarcoma cells of the spindle-cell variety. The ethmoid cells were opened, but very little pus or necrosed bone was encountered. The eye continued to protrude very markedly, and the general health began to fail. An unfavourable prognosis was given, and as a last resort the X-ray was tried by Dr. G. E. Pfahler, Medico-Chirurgical Hospital. For the first month

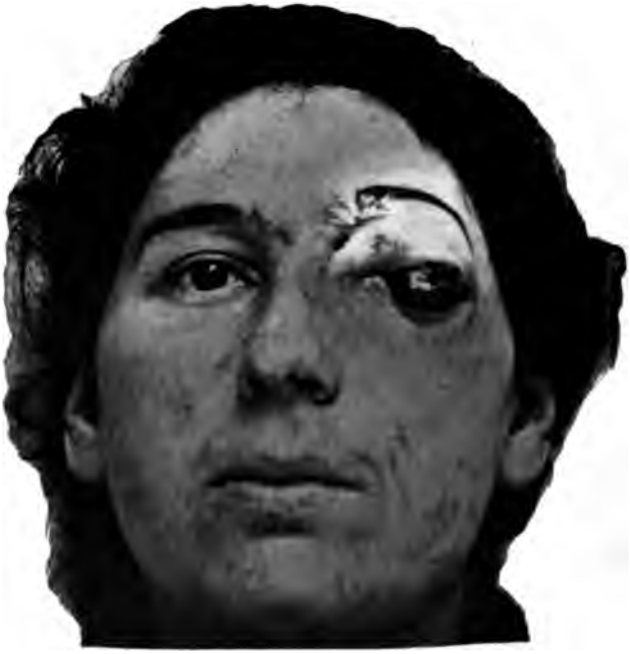

FIG. 160.—SARCOMA OF LEFT ORBIT BEFORE X-RAY TREATMENT. (Author's case.)

twenty-eight applications were made. For the next two weeks three applications were given each week; this was reduced to two for one week, and then once every week until the present writing. The improvement was marked, as may be seen from the accompanying illustration.

Cysts of the orbit include dermoid and echinococcus cysts. They are manifested by fluctuating tumours in the orbit, accompanied by exophthalmos and slight impairment of ocular motion and slight pain. The diagnosis rests upon the examination of the cyst contents subsequent to removal. The echinococcus cyst, however, is not congenital; is of more rapid growth and is accompanied by more pain than a dermoid cyst. The characteristics of these cysts differ in no wise from the same cysts elsewhere in the body. Extirpation of the cysts is the treatment indicated.

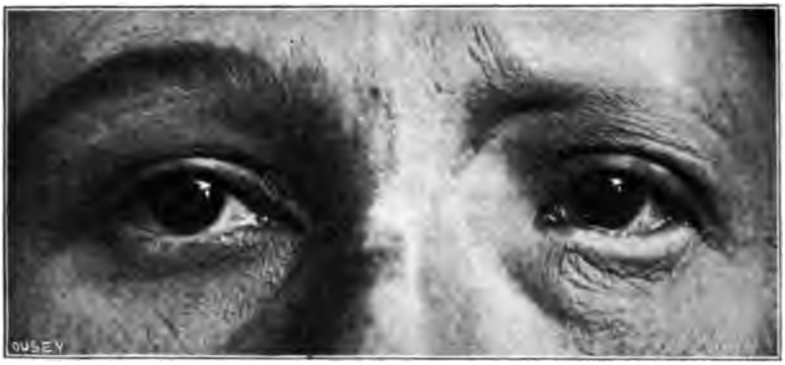

FIG. 161.—SARCOMA OF ORBIT AFTER X-RAY TREATMENT. (Author's case.)

The only case of echinococcus cyst which I have had the opportunity of seeing occurred at Moorfields Eye Hospital, London, under the care of Mr. Robert Lyell, whose assistant I was at the time. Neuritis and optic atrophy preceded the pronounced exophthalmos. After some time sloughing of the cornea followed and the eyeball was removed. At this time the cyst wall was accidentally opened and the fluid gushed out and was followed by complete collapse of the growth. A microscopic examination of some of the fluid confirmed the diagnosis, as the scolices and hooks were plainly seen in large number.

Serous Cyst.—The integument has a glistening, pink colour, slightly translucent, moderately tense, and not adherent to the tumour. The sizes of the cysts vary; they are not pointed, but oval in shape, having their greatest breadth immediately below the skin, while the small or pointed diameter lies buried deep in the orbit. Their point of development, apparently, is from the periosteum covering the nasal bone. They find their way to the surface, expanding where there is least constriction from the tissues, and are of exceedingly slow growth, never interfering with the motility of the eyeball nor movements of the eyelid. These cysts are detected in early life, and, no doubt, like the dermoid, are developed in the embryonic period. The cyst walls, which are thin, fibrinous, and elastic, cannot be easily dissected from the adjoining tissues.

The fluid contents of the sac are clear yellowish, and of the consistency of honey. Microscopic examination reveals an oily fluid filled with fatty, granular masses, large oval cells, similar to mucous cells; no cholesterine crystals or dermoid *débris.*

Treatment.—The application of irritants externally, puncturing the cyst, injecting dilute tincture of iodine, signally fail to give permanent relief. An incision of not less than 6 lines is made with a sharp-pointed bistoury, or Beer's knife, into the sac, making the wound in the horizontal direction, and the contents of the tumour is emptied by gentle pressure. A point of nitrate of silver is then thoroughly applied to the inner walls of the cyst (great care must be observed to apply the caustic to the lower part of the cavity); by this procedure the inner walls are destroyed, thereby creating two inflamed surfaces which become agglutinated, and the cyst is obliterated. A small pellet of lint is usually kept in the external orifice of the wound for three or four days to prevent closure, as the destroyed tissues will slough, and a slight discharge makes its appearance. For the first six hours after the operation cold dressings are applied; after this, boroglyceride. There is no reaction, the cavity healing rapidly.

The vascular growths are largely congenital and consist of telangiectatic and cavernous angiomata and aneurysms. Pulsation is present in addition to the exophthalmos. They are slow in growth and are attended by very little pain, but should be removed when possible.

The optic nerve is occasionally the seat of a myxoma or myxosarcoma and is attended by exophthalmos, but very little disturbance of motility, owing to the situation of the growth. It enlarges very slowly and induces blindness from pressure upon the optic nerve. The condition may be recognised only by deep palpation. Simple myxomata are benign and do not tend to recur.

The treatment in benign growths consists in removing only the tumour through an opening in the temporal wall of the orbit (Kronlein's osteoplasty). Myxosarcomata require removal of the eyeball and as much of the optic nerve as possible.

The orbital walls may also be the origin of orbital growths. The periosteum may be circumscribedly or diffusedly hypertrophied, resembling a tumour in many respects.

Exostoses are also encountered, originating from the periosteum, usually at the upper border of the orbit. The cause is often injury. Some cases may be of syphilitic origin. They are slow in growth, and are extremely hard and firmly attached to the bone from which they spring. Removal by drilling the base of the growth is indicated. The possibility of syphilis in the etiology should always be considered, and a fair trial given to the mercurials and iodides.

Sarcoma of the orbital walls may occur as a primary growth, but is usually due to extension of the sarcomatous process from other tissues in the orbit. The pain, rapid growth, and exophthalmos are marked.

The adjacent sinuses may encroach upon the orbit as the result of inflammation or tumours. Orbital periostitis or cellulitis, or both, may follow acute purulent inflammation of the frontal, ethmoidal, or sphenoidal sinuses or the antrum of Highmore. Such cases are encountered with greatest frequency in the course of the infectious fevers, such as influenza, scarlet fever, and pneumonia. The acute orbital complications induce exophthalmos, pain, and impairment of motility resembling orbital tumours. They are less common than those following chronic empyema of the accessory sinuses.

Chronic empyema of the frontal sinus is probably the most frequent of the diseases of the sinuses adjacent to the orbit. It may follow the acute inflammation, but is more often chronic from the beginning. Persistent brow-ache and nasal discharge are constant, but are of no diagnostic importance, as they also accompany ethmoid disease. With the accumulation of pus within the sinus, caries and perforation of the bony wall ensue in an effort to afford a spontaneous discharge of the sinus contents. This process is slow, but is satisfactory as far as the sinus is concerned. The dense periosteum and fascia of the orbit, however, prevent the exit of the pus from the orbit. As the purulent material accumulates in its new location the periosteum is raised and distended, so that it and the fascia with the discharged material form a tense fluctuating tumour to which the term *mucocele* is applied. The material within the cyst-walls is at first true pus, but later, by precipitation and retrograde changes, becomes a somewhat thin mucoid fluid. The frontal sinus may also discharge itself anteriorly in the region of the eyebrow. In such cases the skin is likewise perforated and a fistula remains. The mucocele of frontal sinus disease by reason of its location induces exophthalmos downward and outward, and this may aid the diagnosis materially.

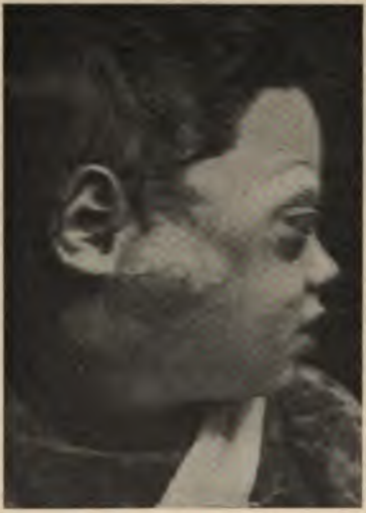

FIG. 162.—MALIGNANT ORBITAL GROWTH; GLIOMA. (Author's case.)

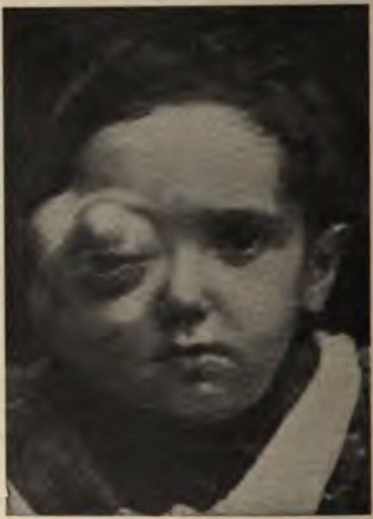

FIG. 163.—SAME CASE AS FIG. 162 AT LATER PERIOD.

Treatment.—In all cases it is necessary to afford free drainage for the purulent material. All diseased portions of the bony wall should be removed and the sinus should be thoroughly antisepticized. In acute empyema an incision should be made in the inner third of the eyebrow and a small opening should be made in the bony wall beneath the supra-orbital ridge. The lining membrane of the sinus is opened and its contents removed by irrigation with a bichloride-of-mercury solution (1 to 5,000). A probe should then be passed to determine whether or not a free communication with the nasal passages exists. The cavity of the

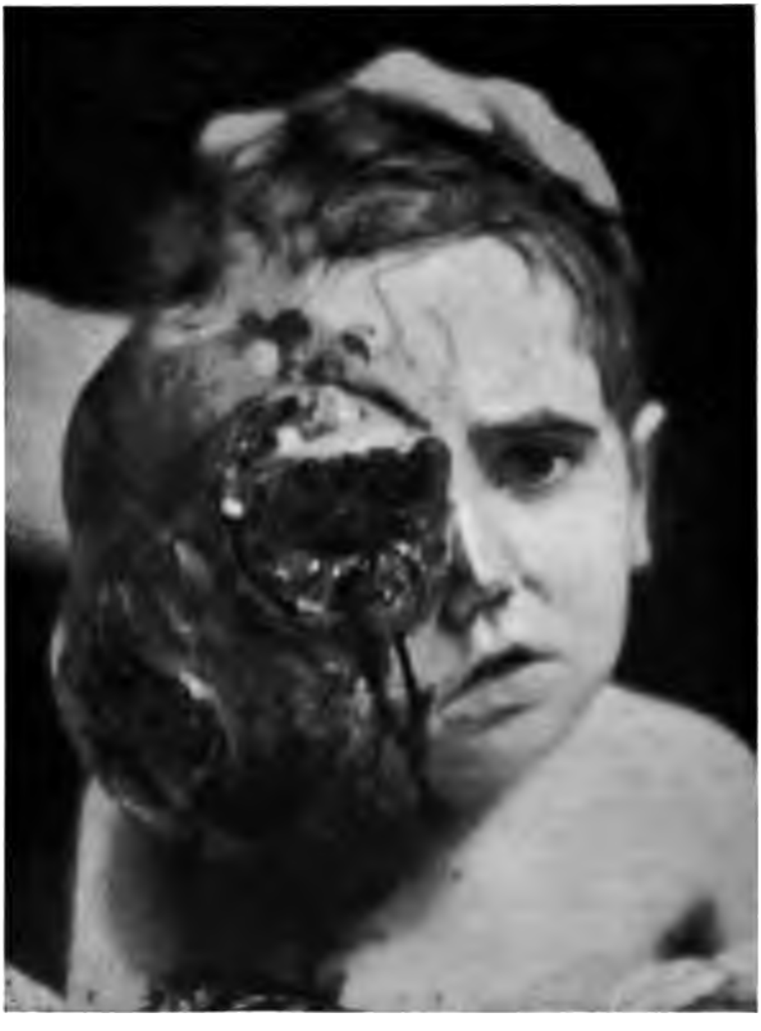

FIG. 164.—SAME CASE AS FIGS. 162, 163; PHOTOGRAPH TAKEN ONE WEEK BEFORE FATAL TERMINATION.

sinus should then be packed with antiseptic gauze, which should be changed daily. Irrigation of the cavity should always precede the introduction of fresh gauze.

In chronic empyema of the frontal sinus there are two principal forms of treatment. In one the sinus is completely opened and all diseased bone and other material thoroughly scraped away, after which the cavity is packed with gauze and allowed to heal up from the bottom, thus obliterating the sinus. As originally performed this was attended by good results, but also by considerable deformity, so that it has since been modified, retaining the upper orbital margin and the periosteum. The injection of steam into the sinus has been employed for its obliteration. In the second treatment the sinus is carefully curetted and irrigated, after which a free communication is established between the frontal sinus and nasal passages. A rubber tube is passed through this opening to afford drainage. Irrigation is then practised daily. In both forms cure occurs, but a rather long period of time is required.

Osteoma of the frontal sinus occasionally occurs, and is usually located at the upper inner angle of the orbit. It is not infrequently associated with chronic empyema of the sinus. The growth is dense and possesses the usual characteristics of osteoma. Although extirpation is indicated, it must be remembered that the risk attending it is considerable.

Disease of the ethmoidal sinus may be followed by extension of inflammation to the orbital cellular tissue in acute cases, or it may induce a fluctuating tumour or mucocele at the side of the orbit. The nasal passages should always receive careful attention in affections of this sinus. In the chronic form a curved incision should be made from below the inner third of the eyebrow to the inner canthus, keeping to the inner upper side of the pulley of the superior oblique (H. Knapp). All diseased bone should be thoroughly scraped away and the cavity freely irrigated. The passing of a tube into the nose is necessary to maintain free drainage. Daily irrigation is also required.

Tumours of the ethmoid, such as carcinoma and sarcoma, are occasionally encountered and pursue their usual malignant course. The orbit is encroached upon by their growth, and exophthalmos is an early symptom. Removal of the growth should be performed if possible, but seldom if ever succeeds in checking the affection.

The sphenoidal antrum in rare instances gives origin to bony tumours, polypi, and sarcomata that encroach upon the orbit. They are seldom diagnosed in their early stages, and frequently the first symptom noticed is blindness, most marked on the temporal side of the field. Examination of the nasopharynx at this period will reveal the presence of a sphenoidal growth. Removal of the growth is indicated, but is always difficult and often impossible.

The maxillary antrum or **antrum of Highmore** may also be the seat of malignant tumours that may erode the floor of the orbit, causing the eyeball to be displaced upward and inward or upward and outward. The growth within the superior maxilla enlarges in all directions, so that the cheek is broadened, the nose is displaced, and the roof of the mouth is pushed downward. Pain is present, due to the pressure and irritation upon the fifth cranial nerve. Nasal discharge is sometimes present. The treatment consists usually in resection of the superior maxilla, and the prognosis is unfavourable.

Encephalocele or hernia of the brain is occasionally encountered as a cause of exophthalmos, and should not be confused with the various ocular tumours. It is due to a prolapse of a portion of the dura through some congenital aperture in the orbital roof. It is usually cystic in character, containing cerebrospinal fluid, although in some cases brain matter is inclosed. The tumour is most often situated at the upper inner angle of the orbit and may be reduced by pressure. Symptoms of increased intracranial pressure, such as convulsive movements and twitchings, accompany its reduction, and are of diagnostic significance. The condition is congenital and is not amenable to treatment. The prognosis is very unfavourable, as the affection ultimately terminates in death.

Intracranial tumours seldom invade the orbit, but such an occurrence should be always regarded as a possibility. Tumours of the middle fossa of the skull have been recorded to have pushed their way into the orbit through the sphenoidal fissure and optic foramen. Such tumours are usually recognised by the ocular symptoms they induce, such as hemianopsia and choked disk, long before there is any extension to the orbit. Treatment is of no avail in this class of cases, and the outlook is hopeless.

Dislocation of the eyeball is an infrequent condition, but deserves consideration, as the attending exophthalmos may cause it to be confused with some grave orbital condition. More or less injury to the optic nerve and consequent impairment of sight usually attends this injury. The globe should be reduced by pressure, and maintained in position by a pressure bandage.

Diagnosis.—From the foregoing descriptions it may be readily seen that exophthalmos is an accompaniment of a number of affections of the orbit and adjacent structures. Most of these are serious conditions, and the protrusion of the eyeball in such cases is unilateral. Bilateral exophthalmos is seen in myopia and exophthalmic goître. The distinction between these affections rests upon the condition of the refraction and the presence of increased cardiac activity and enlargement of the thyroid gland in the latter condition. Other symptoms are present in exophthalmic goître, but these are the most characteristic. In all affections limited to one orbit the protrusion of the eyeball is monolateral. The exophthalmos is directed straight forward in inflammatory conditions of the orbit, œdema of the surrounding structures, ocular paralyses, and exophthalmic goître. This should be constantly borne in mind, as the direction of the exophthalmos is oblique in orbital tumours due to the uneven pressure they exert. Orbital tumours grow from one wall of the orbit and push the globe to the opposite side as well as forward. Tumours of the optic nerve and others situated at the apex of the orbit produce no lateral displacement. Exophthalmos slowly produced is suggestive of benign growth, while that induced rapidly indicates cellulitis or some very malignant tumour.

To determine the character of the condition inducing the exophthalmos in a given case it is necessary to employ palpation. This determines the location and consistency of the growth if any is present. Comparison with the unaffected orbit should not be neglected, as it aids the examination materially. Tenderness and pain on palpation nearly always indicates inflammatory conditions, while the presence of a thrill points to vascular disturbances.

Visual disturbances are of value in the diagnosis. In the early stages diplopia is constant, but as the pressure increases upon the optic nerve blindness follows in the affected eye and the diplopia is completely effaced. In tumours located upon the optic nerve or very far back in the orbit, optic neuritis and subsequent optic atrophy may occur before any exophthalmos is produced.

Pain is present in nearly all cases due to the pressure upon the fifth nerve, but in sarcoma and carcinoma it assumes a peculiar character, distinctive of those tumours anywhere in the body.

The impairment of ocular motility may also aid in locating the cause of the exophthalmos. In tumours situated within the muscle-cone, such as those affecting the optic nerve, perfect muscle-equilibrium is maintained. If the tumour is situated outside of the cone there is loss of motion of the muscle corresponding to the side on which the tumour is located.

Pathologic conditions of the adjacent sinuses inducing exophthalmos require most careful examination for their recognition. The presence of a mucocele or a fistula always indicates chronic disease of the sinus, with which it lies in contact or communicates. The tumours of these sinuses encroach upon the orbit only from one direction, that corresponding to the sinus from which they originate. An examination of the nasal passages should also be made in these cases.

Intracranial growths extending to the orbit may be distinguished from other growths by the optic neuritis and optic atrophy that precede their extension.

The character of a tumour in any case is seldom determined before its removal.

Treatment in General.—Tumours limited to the eyeball require enucleation. Cysts of the orbital tissue necessitate excision. Bony tumours growing from the orbital walls may be excised except when involving the roof of the orbit. Inflammation of the cellular tissue should receive the ordinary treatment for inflammation, care being taken to perform incision early. Inflammatory disease of the adjacent sinuses is best treated by affording free drainage through the nose. Exophthalmic goître should receive the ordinary treatment indicated in such cases. Malignant tumours arising from or attacking the eyeball, orbital tissue, bony walls, or adjacent sinuses require exenteration of the orbit. Excision of the bone in these cases of bony origin is also employed. The application of the X-ray may be of value in those cases unaccompanied by metastasis. Occasionally obscure orbital growths are encountered that are retarded by antisyphilitic treatment, and in all cases a fair trial should be given the mercurials and iodides.

Prognosis.—Unilateral exophthalmos is always an unfavourable sign.

The accompanying pressure induces disturbances of muscle-equilibrium and impairment of vision from changes in the optic nerve. In more severe cases the eye is entirely lost, and in malignant tumours life is endangered.

Enophthalmos is a condition in which the eyeball is retracted. This may follow emaciating diseases, but is most marked after traumatism. It may be induced by paralysis of the sympathetic, cicatricial contraction, fracture of the orbital bones, and palsy of the inferior oblique, and seldom makes its appearance until several days or weeks after the receipt of the injury. Treatment is of no avail.

CHAPTER XVIII

THE RELATION OF OCULAR AFFECTIONS TO GENERAL DISEASES

Ocular Disorders in Constitutional Diseases.—The affections of the economy as a whole that influence the condition of the eye most often are syphilis, tuberculosis, Bright's disease, diabetes, rheumatism, leucæmia, chronic intoxications, hysteria, impaired metabolism, intestinal parasites, pyæmia, and consanguinity of parentage.

The relation between syphilis and the various diseases of the eye is well known, acutely inflammatory affections of the anterior segment of the eye being common in the early stages, while chronic affections of the posterior segment are particularly distinctive of the later stages of the disease. Gummas may induce exophthalmos when located in the orbit, and papillitis if situated along the course of the optic nerve-fibres or in the brain. Palsy of the extra-ocular muscles is often due to syphilis. Chronic interstitial keratitis is nearly always a manifestation of inherited syphilis.

Tuberculosis seldom affects the eye as an inflammatory condition or growth of its various structures, although such conditions have been described, but usually predisposes towards the ordinary affections of that organ by the marked lowering of body tone it induces. The so-called "scrofulous diathesis," although indefinite in its pathology, is a well-known clinical condition, and it is in these cases that chronic inflammatory diseases of the anterior portion of the eye are most frequent.

Bright's disease nearly always produces ocular conditions particularly distinctive of it alone. Temporary loss of vision, complete or partial, may be uræmic in character. Albuminuric retinitis is an early and very characteristic symptom of the condition. Puffiness of the eyelids upon rising in the morning is said to be an early symptom of renal dropsy.

Rheumatism is particularly prone to induce iritis, but may also be a contributory factor in the production of other ocular diseases.

Diabetes is often associated with cataracts, and less frequently with retrobulbar neuritis and retinitis.

Extra-ocular palsy, neuroparalytic keratitis, iritis, and hæmorrhagic retinitis are also occasionally found in connection with diabetes; xanthoma, a growth of the eyelids, is often due to this disease.

Leucæmia is characterized by peculiar eye-ground changes; the whole fundus is unusually pale yellow in appearance in both eyes, and there is a marked tendency towards hæmorrhage, the remnants of which are found in all stages of absorption. Chronic iritis, vitreous opacities, and exudations into the chorioid and optic nerve have been observed in this disease.

Pernicious anæmia is also attended by a distinctive fundus picture. There is a diffuse inflammation of the retina with marked œdema, pallid colour of the blood-vessels, and a dirty greenish-white appearance of the optic disk intensified by the yellowish background of the rest of the fundus.

Chronic intoxications that affect the eye include alcohol, tobacco, quinine, lead, methyl alcohol, etc., all of which induce chronic retrobulbar neuritis and consequent alterations in vision.

Hysteria is attended by marked activity of the extra-ocular muscles, and not infrequently is associated with temporary blindness. In hysteric and neurasthenic individuals dilatation of the pupil is nearly always present.

Impaired metabolism is responsible for the continuance of a number of chronic inflammatory conditions of the conjunctiva, especially in children in whom improper feeding is a constant accompaniment. As an example may be mentioned phlyctenular disease. It is probable that the muscæ volitantes arise from this source, as they are most marked during periods of indigestion.

Intestinal parasites may be considered as general affections when their embryos are liberated and allowed to enter the bloodstream and lodge in peripheral portions of the body. Should these embryos reach the eye and develop there they may destroy that organ absolutely. This is a very rare condition, the cysticercus, the larva of the tape-worm, being most frequently found.

Pyæmia, particularly after childbirth, occasionally gives rise to metastatic abscesses in the eyes. One eye is usually involved, and the symptoms are those of panophthalmitis.

Consanguinity of parentage is always attended by some vague constitutional disturbance, as is evidenced by the peculiar conditions so frequent in such children. As a prominent example may be mentioned retinitis pigmentosa.

Rhachitic subjects are often observed to be affected by interstitial keratitis, phlyctenular disease, and lamellar or zonular cataract. The true relation between these affections is not well understood, but it is more than likely that the nutritional disturbances incident to rhachitis are factors of great importance.

Hæmophilia, a rare condition characterized by profuse hæmorrhage upon the slightest wound or injury, may be followed by orbital hæmorrhage or retinal hæmorrhage with subsequent retinitis proliferans.

Myxœdema, another rare affection, may involve the eyelids or optic nerve with contraction of the visual fields and amblyopia.

Ocular Disorders in Diseases of the Nervous System.—In all conditions in which the intracranial pressure is raised choked disk and optic neuritis are present. To this class belong brain abscesses and tumours. The occurrence of tumours, including aneurysms, induce other changes, such as hemianopsia, palsy of the extra-ocular muscles, etc., according to their location. Meningitis is accompanied at first by irritative symptoms, such as nystagmus, nictitation, etc., which are replaced later by lagophthalmos, conjugate deviation, optic neuritis, neuroparalytic keratitis, etc.

Insanity is attended by marked variations in the pupil, optic atrophy, chorioidal degeneration, and visual alterations. Operations upon the eye may induce delirium of more or less intensity, particularly iridectomy and lens extraction.

Paresis is associated with various visual disturbances, such as mind-blindness, hemianopsia, etc. The pupils are unequal and accommodate for distance, but do not respond to light. Various ocular palsies are common. Atrophy of the optic nerve is common. Ptosis, twitching of the eyelids, nystagmus, and scintillating scotomata may occur in this disease.

Bulbar palsy is often accompanied by optic atrophy, ocular palsies, exophthalmos, nystagmus, conjugate deviation, etc.

Locomotor ataxia is characterized by contracted pupils, which react only for distance, diplopia, optic atrophy with dimness of vision, ocular palsies, various entoptic phenomena, scotomata, colour-blindness, hemianopsia, ptosis, etc.

Paralysis agitans is often accompanied by a bilateral tremor of the upper lid, most marked on closing the lids. Spasm of accommodation, bilateral ptosis, and gray atrophy of the nerve have also been marked.

Disseminated sclerosis is attended by contraction of visual fields, scotomata, and other visual disturbances, nystagmus, tremors of the ocular muscles, isolated paralysis of the ocular muscles, various abnormalities of the pupillary reaction, and optic neuritis.

Inflammation and palsied conditions of the trifacial and facial nerve, may induce symptoms referable directly to the eye by reason of their distribution to the muscles in the orbital region. No distinct ocular condition has been observed as due to them.

OCULAR TROUBLES IN DISEASES OF THE DIGESTIVE TRACT

Teeth.—Many inflammatory diseases of the eye are due to reflex causes, not the least of which are affections of the teeth. This is due to intimate connection between the distribution of the fifth nerve and the nerves of the eye. Affections of the eye attributable to diseased teeth occur frequently, and quite often the family physician is ignorant of the cause, and the disturbing member is allowed to remain.

Dental affections provoke ocular troubles in two different ways: (1) By inflammation or irritation of the trigeminal nerve due to dental affection, causing reflex troubles in a manner similar to that in which neuralgia of the fifth nerve or tic douloureux is produced. (2) By the extension of an inflammatory process of the dental root towards the maxillary sinus, and from thence towards the orbit by continuity and contiguity of structure.

The most frequent reflex ocular troubles are pronounced injection of conjunctiva with epiphora from hypersecretion. In children the relation between dental affection and keratitis and phlyctenular conjunctivitis is more noticeable, this being partly explained by the irritation of the trigeminal nerve.

Schmidt, who has given much study to the paresis of accommodation following dental affections, states that in 92 cases of dental disease observed by him the magnitude of accommodation was 73 times less than that encountered at the same age by other observers, especially Donders. The disappearance of the dental affection induced coincident disappearance of the paresis of accommodation. The amplitude of accommodation being greater in young people, the decrease is more pronounced and more appreciable. The decrease of accommodation occasioned by dental irritation, according to statistics, is found to be more pronounced on the diseased side. Owing to a lack of study devoted to this branch this transient paresis of accommodation in the majority of cases remains unnoticed. Some authors claim that paresis of accommodation is usually of reflex nature; that the irritation of the vaso-motor nerves of the eye provoked by a diseased tooth, increases the tension of the eye; the acceptance of this theory is by no means general. Jacobson considers the cause of this paresis to be due to the relaxation of the muscle of accommodation. Pain in the dental nerves is frequently seen in keratitis and cyclitis, and conversely in dental neuralgia there is found some hyperæsthesia of the nerves of the eye, which makes the contraction of the muscles of accommodation very painful. It is impossible for us to explain the fact that irritation of a sensory nerve may diminish or even suppress the energy of a motor nerve. We know that dental pains and irritation of the trigeminal nerves cause an increase of the intra-ocular tension and often produce attacks of acute glaucoma where there is a predisposition to neuralgia.

Children predisposed to toothache quite frequently develop chorea, limited particularly to the orbicularis muscles.

Dental affections produce reflex symptoms on the side of the facial nerve—for example, blepharospasms and chronic contraction of the orbicularis muscles of the eyelids.

It is important, especially when the symptoms seem vague, that inquiry be made as to condition of the teeth, in order that all obstacles that may be in the way or impede improvement may be removed. There are many instances on record where the removal of a carious tooth was the means of restoring sight. Not infrequently abscesses develop in the lid as the result of abscesses around the teeth, especially the eye-teeth. The author has had hypopyon develop in a cataract patient eight days after extraction of the lens coincidently with an abscess of a tooth. The true relation between these structures, however, is not clear.

Other complications of dental pains are amblyopia and amaurosis. These symptoms disappear after extraction of the offending teeth. In such cases it is not uncommon to find peripheral contraction of the field of vision, pain in the eyes upon reading, dazzling by intense light, and the appearance of the complementary colours, especially when the sight is concentrated. The ophthalmoscope shows nothing abnormal except occasionally a slight haziness in the posterior portion of the retina around the papilla.

The contracted field of vision, amblyopia, and amaurosis are explained by the reflex constrictions of the vessels of the retina—these symptoms being analogous to those observed in the affections of the nose.

I recall two cases of iritis where the extraction of several teeth produced a lessening of the inflammation with its gradual disappearance.

Wiecherkiewicz reports the following observations: Sometimes after the extraction of a diseased tooth, gangrene of the eyelids and orbital abscesses appear; the inflammation attacking the meninges, the patient dies from meningitis in some cases, proving that thorough antisepsis should be observed even in the extraction of a tooth.

Affections of the eye of dental origin may be reflex, inflammatory, or both. The combined form is probably more frequent, the proportion of the constituents varying in each case.

M. Parinaud has demonstrated that in children of five or six years, when they are beginning to lose their temporary teeth, and also in adults, dental lesions, not always apparent, may be the starting-point of osseous or periosteal changes of the inferior orbital border, of fistulæ in the lacrymal sac, or lower lid, and also periostitis of the nasal canal.

It is always well, on the eve of an operation, to make inquiries as to the condition of the teeth, as well as to neuralgia, especially when the patient is to undergo a cataract operation.

Pharynx.—Ocular complications following pharyngeal affections may be attributed also to reflex troubles by irritation of the trigeminal nerve. The presence of foreign bodies in the pharynx, such as fish-bones, bread-crumbs, etc., provoke reflex irritation, watering and contraction of the eyelids on the side corresponding to the affected part of the pharynx, or to the tonsil where the foreign body is located.

Adenoid vegetations in the nasopharynx are responsible for certain apparently obscure ocular affections. Quite recently a case came under my observation in clinic that was hastily diagnosed by myself, and subsequently by other ophthalmologists in this city, as optic neuritis due to an intracranial growth. Some time later the patient consulted Dr. S. Lewis Ziegler, who removed a number of adenoid growths from the nasopharynx, after which the ocular disturbances rapidly subsided.

Ziem observed after tonsillitis and adenoid vegetations of the pharynx reflex ocular troubles—watering, blepharospasm, conjunctivitis, etc.

One of the complications observed several times after diseases of the pharynx and tonsils (particularly diphtheria) is the diminution of the amplitude of accommodation.

Stomach.—These affections may cause ocular troubles in four different ways:

(1) By general weakness, causing lack of nutrition and alteration of the blood.

(2) By absorption of the toxic elements, the result of improper digestion and assimilation of food products.

(3) By congestion of the brain and the organs of vision, induced by circulatory troubles consecutive to abdominal plethora.

(4) By reflex irritation of the sympathetic intra-intestinal plexus (plexuses of Auerbach and Meissner), affecting the organ of vision.

I have observed in several cases of dyspepsia and chronic catarrh of the stomach, muscular asthenopia, fatigue of the retina, photophobia, and perception of complementary images provoked by brilliantly lighted objects. It is probable that all these phenomena are but the manifestation of the general weakness of the economy. In those attacked by diseases of the stomach there is sometimes seen an attack of acute and subacute glaucoma. It is probable, although not yet certain, that weakening of the energy of the general circulation predisposes to circulatory ocular troubles. As to stomach or intestinal hæmorrhages, more or less pronounced, it is a well-known fact that such occurrences give rise to certain ocular troubles. According to Förster, amaurosis from stomach troubles usually occupies the first place in order of frequency. Visual troubles follow hæmorrhage some days after, showing that diminution of the quantity of blood is not the direct cause of amaurosis. Amaurosis is frequently preceded by symptoms of cerebral anæmia, such as weakness, frightful occipital pains, pallor, etc. Viewed by the ophthalmoscope, the retina is of a whitish opacity, extending all around the papilla, which is studded with small and numerous foci of hæmorrhage. The improvement of amaurosis, caused by stomachic hæmorrhages, is observed simultaneously with the resorption of the hæmorrhagic foci and the disappearance of the retinal alterations, the outlines of the papilla becoming stronger and clearer, and the back of the eye at last resuming its normal condition.

Leber, Himly, and Galezowski quote cases of amaurosis following simple gastric irregularity, which disappeared after an emetic or any other treatment for the gastric embarrassment had been administered.

Intestines.—Patients weakened by prolonged or chronic diarrhœa are, according to Förster, predisposed to chronic glaucoma. On the other hand, Wiecherkiewicz observed an attack of acute glaucoma following prolonged constipation. Chronic diarrhœa gives rise to a general weakness of the body, affecting the muscle of accommodation as well as other muscular structures. Intestinal hæmorrhages provoke the same troubles of the eye as those described when speaking of stomach hæmorrhages. Intestinal knots may provoke amblyopia, amaurosis, and paralysis of the ocular muscles. These phenomena are generally attributed to reflex irritation produced by the volvulus. According to recent researches, it would be more proper or correct to treat these phenomena as symptoms of traumatic hysteria, induced by the intestinal affection.

Liver.—Hyperæmia of the liver, while causing abdominal plethora, and consequently venous arrest in the brain, also gives rise to circulatory troubles in the organ of vision. The patients, especially those who work constantly at close range, complain of headache, vertigo, and frontal and orbital pains, all which phenomena are brought about by weakness of the muscle of accommodation. The amplitude of accommodation, which at the age of forty years is from 3 to 5 D., falls in these cases to 2 D. The patients are then obliged to wear their presbyopic correction at an age earlier than under normal conditions. When hyperæmia of the liver is cured (by purgatives and alkalines) the ocular troubles disappear. Opacities in the equatorial part of the crystalline lens have been observed in cases of hyperæmia of the liver. Ocular troubles are also frequently met with in patients suffering from jaundice, hepatic cirrhosis, hypertrophy, etc. The yellowish staining of the conjunctiva is one of the early signs of jaundice and is diagnostic in negroes. A similar staining of the eye-ground may be observed in these cases by using the ophthalmoscope with ordinary daylight for illumination.

Pancreas.—It is not certain whether ocular troubles are complications of disease of the pancreas. It should, however, be remembered that affections of the pancreas, as, for example, sclerosis, atrophy, and calculi, induce a particular form of diabetes mellitus, analogous to that artificially produced in animals by previously extracting the pancreas, and which may give rise to certain ocular troubles, especially retinitis.

OCULAR TROUBLES IN DISEASES OF THE EAR

Some authors have noted optic neuritis, paralysis of accommodation, and other oculomotor palsies after suppurative otitis media, and they believe that the ocular troubles can be caused by ear affections. It is more probable that these ocular troubles are provoked by the same causes, or are coincident with middle-ear disease, without being the consequence.

Styx reports a very interesting case of a young man of twenty-one, attacked by otitis media accompanied in the third week by fever, cephalalgia, vomiting, and constipation. Simultaneously there occurred on the corresponding side apparently slight optic neuritis and paralysis of the external oculomotor nerve.

Wiethe reports a case of orbital abscess complicating suppurative middle otitis.

OCULAR TROUBLES IN AFFECTIONS OF THE GENITAL ORGANS IN WOMEN

The connection between ocular troubles and affections of the genital tract in women has for a long time been the object of special study. Ocular troubles depending upon a lesion of the genital organs in man have been but partially studied, but there is sufficient evidence to warrant the conclusion that affections of the prostate in men probably play the same rôle in the development of reflex ocular troubles as diseases of the uterus in women.

Puberty.—Puberty plays an important rôle in the development of diseases of the eyes. According to Puech, affections of the eye at this age attain their maximum frequency. The development of phlyctenular keratitis, interstitial keratitis, pannus, affections of the uveal tract, the lessening of the sensibility of the retina, and optic neuritis may be frequently observed.

Menstruation.—Certain observers have noted the appearance of ocular troubles during menstruation. Finckelstein examined the visual field during the menstrual period, and found the highest degree of peripheral contraction when the menstrual discharge was most abundant. After menstruation the eye returns to its normal condition. It is very important to recognise the fact that exacerbations of diseases of the eyes may occur during the menstrual period; the tendency towards relapses of chronic iritis at such times has long been established by Michel and Trousseau. Despagnet reported a case of iritis which recurred with each menstrual epoch; Trousseau described a case of iritis with hypopyon which made its appearance at each menstruation in a woman suffering with endometritis. This latter case also relapsed during the corresponding period in pregnancy. There is also a great tendency towards retinal hyperæsthesia and its consequent alterations in vision during the menstrual period. Hasner reports the case of a young girl in whom total paralysis of the common ocular nerve occurred at each period of menstruation.

Amenorrhœa and Dysmenorrhœa.—Jacobson observed ocular troubles caused by amenorrhœa coming on after a chill of the lower part of the body. He also saw a case of acute optic neuritis with consecutive papillary atrophy and apoplexy of the optic nerve and of the retina following amenorrhœa. A doubt arises as to whether the simultaneous occurrence of optic neuritis and amenorrhœa in the preceding case was not casual.

Menopause.—The menopause may occasion functional alterations in the organs of vision. Samelsohn described a case of amblyopia caused by the menopause, which increased to the point of complete amaurosis. By pressure upon the eye the patient experienced severe pain in the orbit. Under proper treatment the vision returned completely after some days. Mooren reports severe cases of optic neuritis developing during this period of life. Liebreich saw retinal hæmorrhage after suppression of the menses. Changes in the eye during the menopause should not be confused with presbyopia, which is normal at this period.

Venereal Abuse.—Masturbation, according to Power, may determine in young girls photophobia, weakness of the muscle of accommodation, asthenopia, and chronic conjunctivitis. It is most likely that these ocular troubles are dependent on hysteria or neurasthenia, engendered, occasionally, by venereal abuse. The author has observed two cases of intense photophobia with failure of accommodation and alterations of vision in young girls directly traceable to masturbation, and which entirely disappeared when the pernicious habit was broken up.

Pregnancy.—During pregnancy there is an increase in the pigment of the skin, including the eyelids. Retinitis, cephalalgia, and gastric pains may develop, as a result of the albuminuria and kidney changes of pregnancy; in a great number of cases these conditions may be regarded as precursors of eclampsia. The presence of albuminuric retinitis during pregnancy may oblige the physician to produce premature labour, the result of which after a short time is the restoration of sight. De Lapersonne observed a case of albuminuric retinitis in a woman six months pregnant. He produced premature labour, and seven or eight days later the visual acuity was again normal. A similar case was reported by Dr. A. L. Hudders, of Philadelphia. Albuminuric retinitis accompanied by detachment of the retina does not give a favourable prognosis, as incurable blindness remains in the majority of cases.

The uterus in a pregnant state may provoke ocular troubles analogous to those produced by uterine diseases. The most probable theory of these reflex troubles is that of Brown-Séquard—in which the appearance of vaso-motor troubles is believed to be consecutive to irritation of the sympathetic system. This theory also explains contraction of the field of vision, weakness of the muscle of accommodation, lacrymation, and development of exophthalmic goître during pregnancy. Amblyopia during pregnancy is undoubtedly always the result of albuminuric retinitis.

Weakness of the muscle of accommodation may show itself in the first months of pregnancy and may end in paralysis of accommodation; sometimes, on the contrary, this phenomenon may not occur until confinement.

Amaurosis may be the result of violent hæmorrhages, developing during pregnancy or after confinement.

The development of hemiopia consecutive to very severe hæmorrhage (after confinement) has sometimes been observed. Chevallereau reports one case: In this woman the extraction of the adherent placenta had invoked violent metrorrhœa, the following symptoms being present: Six days after confinement there appeared high fever; at the end of sixteen days partial atrophy occurred, together with loss of memory of substantives; improvement of aphasia began at the end of six weeks; the patient then found that the field of vision had been reduced about one-half. Two years later complete hemianopsia was established.

During puerperal fever the eye may become the seat of embolisms in the retina and septic chorioiditis, causing blindness and atrophy of the ocular globe.

Dangers of Parturition to the Eye of the Child.—Parturition may cause complications not only in the mother's eyes, but also in those of the child. The eyes of the child may be infected in its course through the vagina and attacked by ophthalmia neonatorum, already fully discussed in another chapter of this work. Cases have been reported in which one of the eyes of the child was wounded in the use of forceps. Paralysis of the facial nerve by compression with the forceps is the principal affection the physician encounters, but with proper treatment it can generally be cured.

Pajot described very slight ecchymosis of the superior eyelid, also produced by compression of the forceps, and which may be the starting-point of dermatitis of the eyelids.

Bouchet has seen several cases where compression caused fracture of the frontal bone and exophthalmos which were cured without either paralysis or convulsions ensuing.

Schroeder, after using forceps in a primipara, found exophthalmos and hæmorrhage in the anterior chamber of the eye. The autopsy revealed hæmorrhage into the orbit (hence exophthalmos) and detachment of the dura mater, separated from the bone by the extravasated blood.

Œdema and cicatricial ectropion have been observed by Stanheim as the result of forceps delivery.

The forceps may also cause laceration of one or more muscles of the eye. The result always will be paralysis of the said muscles, recognisable even after several years.

Cases have been reported where both eyeballs were permanently destroyed by a most unfortunate application of the forceps.

Diseases of the Ovaries.—Diseases of the ovaries may induce ocular troubles not connected with hysteria or neurasthenia. Only one case has been reported in favour of this hypothesis, and in it an attack of glaucoma followed puncturing of an ovarian cyst.

OCULAR TROUBLES IN AFFECTIONS OF THE GENITAL ORGANS IN MEN

It may well be supposed that there is a relation between ocular troubles and affections of the genital organs in man; nevertheless, but very few serious observations exist to place this relation beyond doubt. If there be a relation between the two, it is a well-known fact that this quite frequently escapes the attention of the attending physician.

It has been noticed recently that affections of the genital organs cause a disturbance of the functions of other organs than those of vision. Preyer has proved that certain diseases of the stomach, treated for a long time without the least success, were cured or improved after curing the affections of the sexual organs, which gave rise to them by reflex channel.

Masturbation or seminal loss may be reflected in the eye in two different ways:

(1) In causing the development of neurasthenia, it engenders functional disorders of sight, which are but the partial symptoms of nervous diseases.

(2) In weakening the whole economy, it does not exempt the organs of vision.

H. Cohn and Power, during their special researches in ocular troubles in onanists, discovered that those abandoned to masturbation are afflicted with floating specks, photophobia, and that they complain of accommodative asthenopia comparable to that produced in affections of the womb (hysteria kopiopia); reading is very fatiguing; amplitude of accommodation is diminished; and spasms of the eyelids exist. It was also noticed that the patient had a staring look and a large or well-dilated pupil. The influence of the genital tract in the production of functional disorders of the eye was quite recently exemplified by two men who consulted me for intense photophobia, retinal hyperæsthesia, and failure of accommodation. After exhausting the usual therapeutic measures for these conditions, and without any improvement, urethral sounds were passed under my direction by Dr. S. L. Gans, of the Medico-Chirurgical Hospital, dilating the urethra to its fullest calibre, after which prompt relief was afforded.

An inflammation of the conjunctiva which resists all manner of treatment, and which is similar to inflammations of the pharyngeal and other mucous tracts, is quite frequently met with in these unfortunate individuals.

At the present time it cannot be positively said that onanists are threatened with retinitis, atrophy of the optic nerve, etc., in their old age, for the reason that the connection between such conditions has never been proved.

By some authorities it is claimed that amblyopia is the result of masturbation, although this also has never been proved. It is probable that in a certain number of cases of amblyopia the latter is caused by weakness of the muscle of accommodation, due to a drain on the system through the genital tract.

Milliken observed a case which proved that coitus may accidentally produce eye troubles. When arterio-sclerosis exists, coitus may augment the action of the heart and encourage the development of cerebral hæmorrhage; it is an indisputable fact that apoplectic fits have often been caused by coitus. In those cases of sudden death during sexual intercourse it is probable that the primary cause is cerebral hæmorrhage, and this is no doubt preceded in many instances by retinal hæmorrhages. When the hæmorrhage is not great enough to induce death, incurable visual alterations are frequent. In Milliken's case, left homonymous hemianopsia occurred during coitus, probably produced by meningeal apoplexy of the left occipital lobe.

Exophthalmic goître may occur in the female during an affection of the genital tract; in the male, it may be produced by an analogous cause—but this cause is so seldom considered that it probably often escapes the detection of the attending physician.

By some authorities it is claimed that affections of the prostate in the male may give rise to certain nervous reflex symptoms similar to those seen in the female attacked by disease of the womb. Cataract, chorioiditis, conjunctivitis, etc., have been frequently noticed in men with enlarged prostate glands and other affections of the urethral tract, and when properly treated the eye symptoms promptly improved, and even disappeared altogether in a number of instances. Gonorrhœal ophthalmia, referred to in another chapter, one of the most serious affections the eye can be subjected to, is produced by infecting the eye with the gonococci of the urethral discharge. The treatment, as well as the care of the patient, in such an affection has been fully discussed in another chapter of this work.

Ocular Disorders in the Infectious Fevers. — Cerebro-spinal fever is frequently accompanied by pronounced ocular symptoms due to the irritation of the cranial nerves by the inflammatory exudate on the meninges. Nystagmus, strabismus, ptosis, and irregularity and immobility of the pupils occur early in the affection, and later are followed by palsy of the muscles with blindness. As complications during convalescence there may occur keratitis, retinitis, or optic atrophy.

Cholera is attended by no characteristic conditions of the eye during the height of the disease with the exception of the marked shrinking of the orbital tissues, causing the eyes to have a pronounced sunken appearance. During convalescence ulceration of the cornea is not infrequent.

Diphtheria is not infrequently attended by a diphtheritic inflammation of the conjunctiva, but is more often followed by paralysis of accommodation or palsy of one or more of the extra-ocular muscles.

Erysipelas sometimes extends to the skin of their lids, causing their closure. It is sometimes accompanied by other ocular disturbance. Knapp has recorded a few cases of optic atrophy following severe attacks of facial erysipelas.

Hydrophobia is attended by excessive motion at first, and later immobility of the eyeballs, due to involvement of the extra-ocular muscles.

Influenza is accompanied in typical cases by a catarrhal inflammation of the conjunctiva, which is characteristic.

Malaria is attended by conjunctivitis in the ordinary forms: yellowish discoloration of the conjunctiva in pernicious malaria and chronic retrobulbar neuritis in cases of long standing.

Measles is usually preceded in children by a period of one week or more in which there is a marked tendency to close the eyes and sleep. As the rash appears, photophobia, lacrymation, blepharitis, and tiring of accommodation follow, and soon an inflammatory condition of the conjunctiva may be detected.

German measles, or rötheln, is characterized by the occasional appearance of the rash on the lids.

Scarlet fever is seldom associated with any diseases of the eye during the height of the affection, but during convalescence corneal ulcerations and inflammations are not infrequent. Renal changes are followed by the characteristic eye-ground alterations.

Smallpox is not only liable to be accompanied by keratitis, iritis, etc., but the lesions, themselves, of smallpox are not uncommonly situated upon the cornea, causing irreparable damage to the structure. The same conditions are likely to take place in vaccinia and varicella. The author recently removed an eye of a young girl that had been entirely destroyed by smallpox.

In tetanus, as in hydrophobia, the muscles that control the ocular movements are likely to be involved with other muscle structures.

In typhoid, typhus, and similar low fevers, a condition known as *coma vigil,* in which the eyes are wide open and stare directly ahead, the patient being more or less comatose, is of very frequent occurrence.

Acute miliary tuberculosis is characterized by the presence of tubercles in the retina, photophobia, and ocular palsies.

Yellow fever is distinguished at first by contraction of the pupil and conjunctival injection, but later the pupil dilates and the conjunctiva becomes yellow. The onset of uræmia may be announced by blindness.

Whooping-cough is nearly always attended by a subacute conjunctivitis, and sudden hæmorrhage may occur into that structure as the result of severe coughing.

OCULAR TROUBLES IN AFFECTIONS OF LYMPHATIC GLANDS

In patients attacked by polyadenitis the development of small tumours like buttons in the iris and the chorioid is sometimes seen. These tumours when situated in the chorioid may determine clinical symptoms of disseminated chorioiditis.

In a case of polyadenitis, Koenigstein found small lymphatic tumours in the liver, the lungs, the brain, and small analogous tumours in the optic nerve as well as the oculomotor nerve. The ophthalmoscope revealed the existence of optic neuritis on one side, and very intense neuroretinitis on the other. Total unilateral ophthalmoplegia was present, caused by the compression of the tumours on the motor nerve of the eye at the entrance into the orbit.

Anatomical examinations of the tumours in these cases show that they consist largely of a mass of leucocytes. Polyadenitis attacks the male sex especially, and is characterized by the inflation and induration of the lymphatic glands.

The treatment is general in character, and it is of the utmost importance to inquire into the patient's general condition in order to improve the ocular affection. Salt and iodine baths and arsenic constitute the means usually employed.

OCULAR AFFECTIONS IN DISEASES OF THE RESPIRATORY TRACT

The extension of chronic rhinitis up the nasal duct is often a cause of persistent conjunctivitis. Less common are the various inflammatory conditions of the lacrymal apparatus. Some observers have shown an intimate relation between certain forms of rhinitis and chorioiditis. It is probable that there is a syphilitic constitution underlying such cases.

Following serious catarrhal affections of the respiratory mucous membrane there is often the appearance of herpes on the cornea. This is characterized by vesicles filled with thickened or slightly limpid substance. It appears immediately after the crisis of a fever, simultaneously with nasal and labial herpes, being accompanied by intense pain, watering, and slight pericorneal injection. The vesicles burst in time and ulcerations form in their stead. The loss of substance is considerable, especially in those cases where the ulcerations are confluent. The cornea is anæsthetized in the affected areas. The eyelids and forehead remain intact, which distinguishes this affection from herpes zoster. Its duration generally is from a month to six weeks, and usually is unilateral. In a recent case under my observation herpes corneæ febrilis lasted four months.

Following a violent cough (whooping cough, chronic affections of the respiratory channels, etc.) hæmorrhages appear in the subcutaneous tissues of the eyelids and the conjunctivas. These hæmorrhagic foci are superficial, subepithelial, and are formed by the rupture of capillaries, which are found on the summit of the papillæ of the dermis. In some instances the hæmorrhage is so considerable that the eyelids are of a bluish colour.

Hæmorrhagic foci appear in those killed by asphyxia, hanging, and strangulation, their importance being recognised from the standpoint of legal medicine.

Circulatory disturbances also cause retinal hæmorrhage, as in pulmonary emphysema, emboli of the pulmonary artery, and cyanosis consecutive to respiratory troubles, where there is simultaneous formation of hæmorrhagic foci in the retina and in the conjunctiva. This is especially observed in cases where death has been preceded by symptoms of suffocation.

In the newly born cyanosed child hæmorrhagic foci are seen in the posterior part of the retina, caused by difficulty of respiration and probably also by compression of the head during birth. Difficulty of circulation of venous blood in chronic diseases of the lung (emphysema, for example) passes into venous stasis in the retina, and can be readily distinguished by the ophthalmoscope. Thus in emphysematous patients dilatation of the retinal veins is very frequent. There is also sometimes in these individuals thrombosis of the central vein of the retina.

OCULAR DISORDERS IN DISEASES OF ADJACENT SINUSES

The close proximity of the frontal, ethmoid, sphenoidal, and maxillary sinuses to the orbit make clear the necessity of distinguishing the affections common to them. The symptom of exophthalmos is present in all and is due to the encroachment of the sinus disease upon the orbit. No other symptom besides the protrusion of the eyeball is noticed, thus differing from tumours of the nerve and other ocular growths. Sometimes the condition that gave rise to the sinus inflammation affects also the eyeball, including various chronic inflammatory diseases.

OCULAR DISORDERS IN DISEASES OF THE SKIN

Owing to the fact that the outer layer of the eyelids is composed of skin, it is possible for these structures to be affected by any of the skin diseases. They may have their origin in the lid alone or may extend from adjacent areas. The most common of these affections are described at length in the chapter on Diseases of the Eyelids.

A more interesting subject is the relation that exists between phlyctenular disease and vesicular eczema of the face. Their almost invariable simultaneous occurrence has led some observers to term the conjunctival condition eczematoid conjunctivitis. It is more than likely that eczema is merely a coincidence and arises from the same nutritional causes as the ocular condition, although occasionally it seems secondary to the ocular discharge. Both diseases, however, nearly always disappear at the same time.

The dermal manifestations of syphilis should always be sought for, as frequently the diagnosis of a previously obscure inflammatory case will be made clear upon the finding of some evidence of syphilis upon the skin.

It should also be remembered that pustular and vesicular diseases in the ocular region show a marked tendency to extend, and their extension to the eye is always attended by more or less destruction of tissue.

OCULAR TROUBLES IN AFFECTIONS OF THE THYROID GLAND

From the pressure which they exert on the cervical sympathetic, tumours of the thyroid gland may provoke dilatation of the pupils, a fact that has been already referred to in another chapter. In exophthalmic goître, Graves's disease, or Basedow's disease certain observers have demonstrated the fact that dilatation of the pupil may be brought about by exercising pressure with the finger upon the thyroid gland, even when it is not diseased. Ocular phenomena are particularly prominent. Bilateral protrusion of the eyeballs is especially well marked, and the upper lid fails to follow the globe when the latter is directed downward (Graefe's sign). The palpebral angle is abnormally widened (Stellwag's sign). The exposure of the cornea often leads to ulceration of that structure. Usually the vision is unaffected. Other ocular conditions have been observed, but it is probable that these were mere coincidences, and not the result of the goître. Simple goître and other affections of this gland hinder the circulation of the blood in the jugular vein, and the sanguine stasis that results may cause, in predisposed subjects, attacks of glaucoma. Kirschbaumer has noted the frequency of glaucoma in patients suffering with goître.

Landesberg has published an observation of cataract which was regarded as the result of a strumous cachexia. It occurred in a girl of twenty-five years, from whom Bergmann had extracted the thyroid gland two years previously. Soon after the operation had been performed epileptic fits developed, and one year later eye troubles became prominent. Two years after the ablation of the goître the patient presented herself to Landesberg, who found in both eyes opacity of the anterior layers of the crystalline lens; in the right eye adhesions existed between the iris and the crystalline lens. After the cataract operation very fine opacities (dust-like) were observed in the vitreous body. Landesberg believed that the alterations of the vitreous had been produced by a chronic affection of the uveal tract. First came chorioiditis (opacities of the vitreous body), then iritis (posterior synechiæ), and finally cataract. The alterations were analogous to those observed sometimes following typhoid fever, variola, erysipelas, etc.

For more complete details of the relation of the eye to general diseases the reader is referred to the valuable works of Berger, Knies, and Linnell on the subject.

CHAPTER XIX

THE PUPIL IN HEALTH AND DISEASE

UPON examination of the pupil in the ordinary light of the room, it will be seen to be circular in shape or oval, with the long axis at 90 degrees, and situated slightly to the nasal side of the centre of the cornea. It appears absolutely black for the reason that no light is reflected from the retina, and it becomes red in colour only when the interior of the eye is made a source of illumination, as in examination by means of the ophthalmoscope. The average diameter is about 4.14 millimetres. The pupils are usually equal, but occasionally the left is found to be the larger. The measurements may be taken by means of the ordinary millimetre rule or by means of the pupillometer, a disk of glass upon which circles of varying diameters are drawn. The pupillometer is held close to the eye and the circle that corresponds to the circumference of the pupil indicates its size.

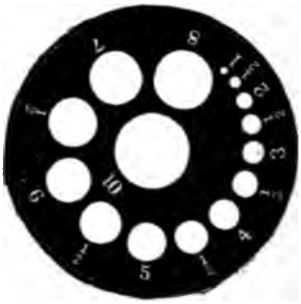

FIG. 165.—PUPILLOMETER.

The pupil is mobile, being capable of altering its diameters under the influence of various internal and external causes. It admits of three variations—rest, contraction, and dilatation—all of which depend upon the action of the circular and radiating fibres of the iris and their nerve-supply. The condition of rest is only relative, being a condition midway between contraction and relaxation, a condition of muscle-tone, in fact, due to a reciprocal relation existing between the contractor and dilator nerves. Absolute rest is relaxation; but here, as elsewhere in the body, partial contraction is considered as rest.

In order to effect a departure in the condition of the pupil from that of rest, it is necessary to stimulate or depress either set of nerves supplying the iris. Contraction is induced by the stimulation of the oculomotor nerve and depression or paralysis of the sympathetic nerves, while dilatation results from stimulation of the sympathetic nerves and depression of the oculomotor nerve.

A knowledge of the details of these phenomena is of great value in determining the significance of the pupillary condition. Contraction is usually brought about by rays of light falling upon the retina in concentrated form. Afferent impulses are conducted from thence by the optic nerve to the centre for pupillary reaction. The existence of this centre is undoubted, and it is believed to be located below the corpora quadrigemina in the anterior portion of the floor of the aqueduct of Sylvius. Contrary to what would be supposed, there is but one centre governing both eyes, thus accounting for such a phenomenon as consensual reaction. Efferent impulses are despatched from this centre along the fibres of the third cranial or oculomotor nerve to the circular fibres of the iris or sphincter pupillæ, which, by their contraction, produce narrowing of the pupil or myosis.

In proof of this explanation of the manner in which contraction takes place, it has been shown that the pupil fails to contract when the retina is exposed to bright light if the third nerve has been severed, and that stimulation of the peripheral portion of the nerve alone will induce contraction under such circumstances. Further, stimulation of the centre in the floor of the aqueduct of Sylvius will induce contraction in the absence of light, and the removal or destruction of the centre will render light thrown upon the retina ineffectual in bringing about pupillary contraction. There is also some intrinsic ganglion in the iris itself, as is shown by the contraction that sometimes occurs when the eyeball is removed. The presence of some depressing influence upon the sympathetic nerves supplied to the iris is also necessary to bring about contraction of the pupil.

Dilatation of the pupil is brought about by contraction of the radial fibres of the iris and of the blood-vessels of the iris, the latter causing a condition of temporary anæmia in that structure. The pathways for the afferent impulses in this phenomenon are various and include the optic, the trifacial, and the sympathetic nerves throughout the body. The efferent impulses are conducted by the sympathetic nerves. The centre for dilatation is situated in the anterior portion of the floor of the aqueduct of Sylvius just behind the centre for contraction. The efferent impulses are then

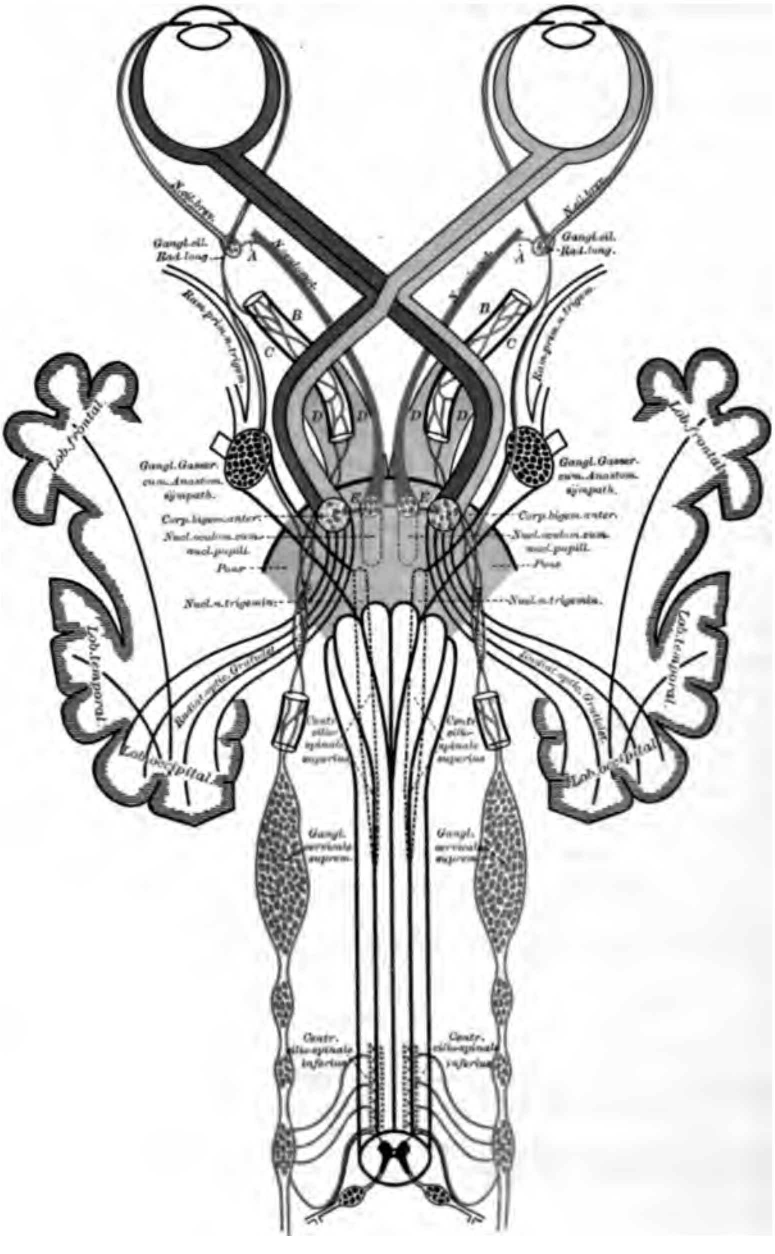

PLATE V.—DIAGRAM SHOWING ORIGIN OF PUPILLARY REACTION.

conducted to the medulla oblongata, and from there to the inferior cilio-spinal centre in the upper dorsal or lower cervical cord. This centre is believed to be capable of governing dilatation of the pupil independent of the centre in the brain. From this centre the impulses travel along the roots of the upper dorsal and lower cervical spinal nerves to the *rami communicantes,* and from thence to the upper thoracic ganglion. The sympathetic nerve carries the impulses from this ganglion into the skull following the course of the great blood-vessels, eventually reaching the iris. The nerve is in close communication with all the nerve-filaments of the iris—namely, the ciliary ganglion, the short ciliary nerves, the oculomotor nerve, and the ophthalmic division of the fifth nerve. That the sympathetic nerve is concerned in the dilatation of the pupil is proved by the marked contraction that follows division of the nerve and the subsequent dilatation that follows stimulation of its peripheral portion. Although dependent to a large degree upon the influence of the sympathetic nerve upon the blood-vessels of the iris, it is not entirely so, as has been shown by the dilatation that may be induced in the bloodless eye.

The local action of certain drugs when instilled into the eye has further demonstrated that the mobility of the pupil is also governed by an intrinsic ganglion resident in the iris itself.

Reactions of the Pupil.—These may be external in origin, as in the reaction to light, accommodation, and convergence; or internal in origin when due to fright, pain, emotion, and other disturbances of the sympathetic system. Their significance varies according as the cause is physiological or pathological. The pupil contracts in the presence of light and dilates in its absence except in sleep. Accommodative effort is attended by contraction of the pupil, as is also convergence. These usually occur simultaneously; myosis may take place with accommodation alone, but not with convergence. For instance, in atropine mydriasis, the power of convergence is intact, but the myosis is prevented by the atropine.

Consensual reaction is the reaction that takes place in an eye excluded from the light simultaneously with the eye exposed. It may be observed by shading one eye and having the other directed towards a bright light; contraction should take place at the same time in both pupils in the absence of any diseased conditions.

This phenomenon is explained by the single centre in the brain which governs the pupillary reactions.

Hippus is the term employed to designate a chronic spasm of the iris, as is seen in hysteria, neurasthenia, epilepsy, meningitis, and various spinal diseases, but is also used to describe the unsteady or oscillatory movement of the pupil in changing from dilatation to contraction or rest. A dilated pupil when exposed to influences that induce contraction becomes contracted at once, but dilates again to be followed by a subsequent contraction, and so on until a condition of equilibrium is established. It probably arises from the diminution in the light supply by the contraction which induces the subsequent dilatation.

Oscillation of the pupil also occurs synchronously with the heart-beat and respiratory movements.

Wernicke's hemiopic pupillary reaction consists in contraction of the pupil by exposure of the blind portions of the retina to light if the cerebral lesion is posterior to the pupillary centres, and an entire absence of reaction if the lesion is anterior to those centres.

The Argyll Robertson pupil is one in which the reaction to light is lost, but the reaction for accommodation and convergence is preserved. It is a common symptom in locomotor ataxia and paresis.

Anisocoria is the technical term of the inequality of the pupils, a condition rarely present in health. It is a symptom of insanity, paresis, locomotor ataxia, and similar grave affections. Unilateral blindness, anisometropia, dental disease, and aneurysm may also induce it.

Orbicularis pupillary reaction consists in the prompt contraction of the pupil that follows an attempt to forcibly close the lids. It is also explained by the intermingling of the nerves of the iris with a facial and trifacial nerve and is reflex in character.

The cerebral cortex reflex is also known as Haab's reflex, and consists in marked bilateral contraction of the pupils brought about by directing the gaze towards some bright object in a darkened room independent of accommodation or convergence.

Paradoxical reactions of the pupil are occasionally observed in hysteria and meningitis, and consist in dilatation on exposure to light and contraction upon its withdrawal.

Conditions inducing Contraction of the Pupils

Myosis

- Stimulation of the oculomotor nerve from any cause.
- Paralysis or depression of the sympathetic nerve.
- Old age.
- Blue irides.
- Hyperopia.
- Occupation requiring work at close range, such as jewelers, engravers, etc.
- Congestion of the iris,
- Abrasion of the cornea.
- Infectious fevers.
- Plethora or general congestion.
- Pulmonary congestion.
- Bronchitis.
- Venous obstruction.
- Mitral disease.
- Early stage of intra-ocular tumour.
- Irritative stage of cerebral diseases, as meningitis.
- Apoplexy (early).
- Depression, paralysis, or degeneration of the posterior columns of the spinal cord
- Optic neuritis (late stage).
- Bulbar palsy.
- Cerebral syphilis.
- Deep slumber.
- Deficiency of aqueous humour, such as follows opening of the anterior chamber.
- Uræmia.
- Beginning of hysteria, and tobacco amblyopia.
- Acute mania in late stages indicating the onset of paralysis.
- Paralysis of the sympathetic as the result of aneurysm, enlarged glands, or other tumours in the neck.
- Opium and its various salts.
- Chloral.
- Physostigmine.
- Eserine.
- Pilocarpine.
- Muscarine.
- Poisoning by
  - Alcoholic extract of squill.
  - Carbolic acid (rarely).
  - Hydrastis.
  - Nicotine.
  - Strychnine.

Conditions inducing Dilatation of the Pupils

Mydriasis

- Paralysis or depression of the oculomotor nerve from any cause.
- Stimulation of the sympathetic nerve.
- Youth.
- Dark irides.
- Myopia.
- Outdoor occupation.
- Psychic disturbances, such as fright, emotion, etc.
- Hyperæmia of the spinal cord.
- Tumour of the cervical region.
- Increased intra-ocular pressure, as in hydrocephalus and encephalitis
- Locomotor ataxia (early symptoms).
- Gastro-intestinal irritation such as results from parasites and inflammation.
- Acute mania.
- Spinal irritation.
- Progressive paralysis.
- Diseases of the nuclear centre of the oculomotor nerve.
- Thrombosis or embolism of the cavernous sinus.
- Pressure on ciliary nerves.
- Anæmia.
- Hysteria.
- Cutaneous stimulation.

Neurasthenia.
Idiocy.
Aortic insufficiency.
Diphtheria.
Diseases of the orbit.
Intra-ocular tumours.
Diseases of the retina, chorioid, and optic nerve.
Glaucoma.
Dyspnœa.
Violent muscular actions.
Subconjunctival injections of normal salt solution.
Neurotic temperament.
Labour pains.
Late stage of anæsthesia.
Chloroform anæsthesia: Pupil is first dilated and then contracted. Firm contraction indicates suspension of the chloroform until dilatation occurs once more.
Sudden dilatation during the administration of chloroform indicates asphyxia.
Sudden dilatation after withdrawal of the anæsthetic indicates the beginning of nausea and vomiting.
Salicylic acid (physiological limit).
Hyoscine hydrobromate.
Cannabis indica (physiological limit).
Atropine (internally and locally).
Bromide of methyl atropine.
Euphthalmine.
Homatropine.
Daturine.
Hyoscyamus.
Duboisine.
Cocaine.
Tropococaine.
Bromism (dilated and immobile).
Acute alcoholism.
Amyl nitrate.
Poisoning by
  Acetanilid.
  Aconite.
  Antipyrin.
  Arnica.
  Apomorphine.
  Conium.
  Digitalis.
  Ergot.
  Gelsemium.
  Hydrastis (late).
  Hydrastinine hydrochlorate.
  Hydrocyanic acid.
  Iodoform.
  Lobelia.
  Nitroglycerin.
  Scillitin.
  Turpentine.

CHAPTER XX

REFRACTION

ELEMENTARY OPTICAL PRINCIPLES

Optics is that branch of physical science which treats of light and vision, the organs of sight, chromatics, and the various phenomena connected with sight.

Light is that form of radiant energy which acts on the retina and renders visible the objects from which it proceeds. It is the result of innumerable undulations or little waves transmitted with inconceivable velocity through a highly elastic medium of excessive tenuity known as ether.

The chief phenomena of light are *reflection, refraction, dispersion, interference*, and *polarization*. From a luminous body light-waves are emitted which proceed in a straight line in every plane and direction with a velocity of about 186,427 miles per second. These lines of direction are called *rays*. The amount of divergence of these rays depends upon the distance from the luminous source, being greatest the nearer the source of light. At a distance of 20 feet the divergence is so slight that for practical purposes rays of light at that distance from their source may be said to be parallel.

In passing from a rare to a dense medium the rays may undergo *absorption, reflection*, or *refraction*, depending upon the density of the medium.

Absorption takes place when part or all of the primary colours of the spectrum are taken up. Substances said to be black in colour are those in which all the primary colours have been absorbed. Opaque and coloured substances absorb only a portion of the rays, the rest being reflected, refracted, or both.

Reflection consists in returning or throwing off of rays from the surface upon which they impinge into the medium from which they came. The ray of light striking upon the polished surface is called the *incidental* ray; that which is returned is known as the *reflected* ray.

The angle formed by the incident ray and a line drawn perpendicular to the plane surface is called the *angle of incidence*, and is equal to the angle formed by the reflected ray and the perpendicular, or *angle of reflection*. The incident and reflected rays are contained in the same normal place with the perpendicular to the reflecting surface.

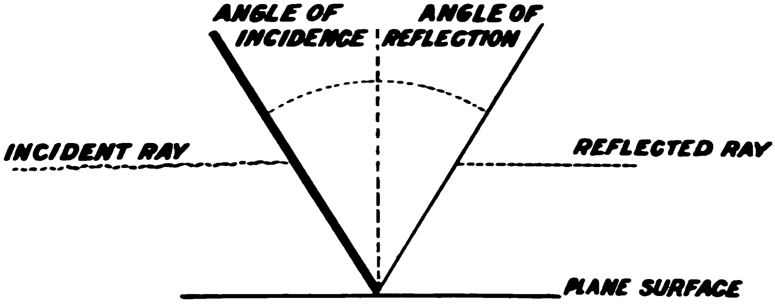

FIG. 166.

Reflection by a plane surface or mirror causes the rays to be returned unaltered in direction (parallel remaining parallel, divergent continuing as divergent, etc.) and give rise to an erect image. The object appears just as far back in the mirror as it is placed in front of it and undergoes lateral inversion. This fact is made use of in the following manner: Cards made with

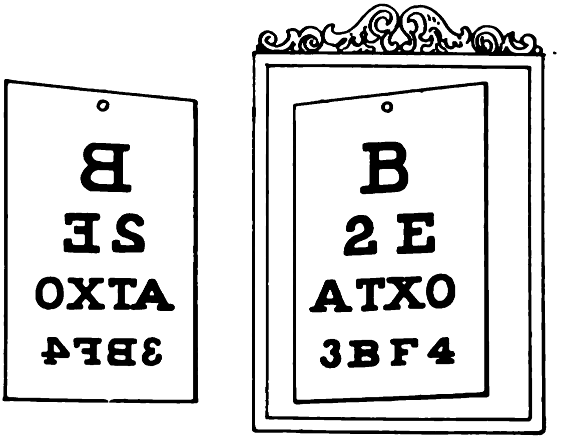

FIG. 167.

test letters reversed are employed for taking vision in small rooms, and by the aid of a mirror the distance from the patient to the test-card can be doubled. For practical purposes the slight change due to inversion may be ignored. Lateral inversion may be easily demonstrated by tilting the mirror, the object appearing to move in the same direction as that in which the mirror is tilted.

The image formed at a distance behind the reflecting surface by the prolongation of the rays is the *virtual image*; that formed by the reflected rays is the *real image*.

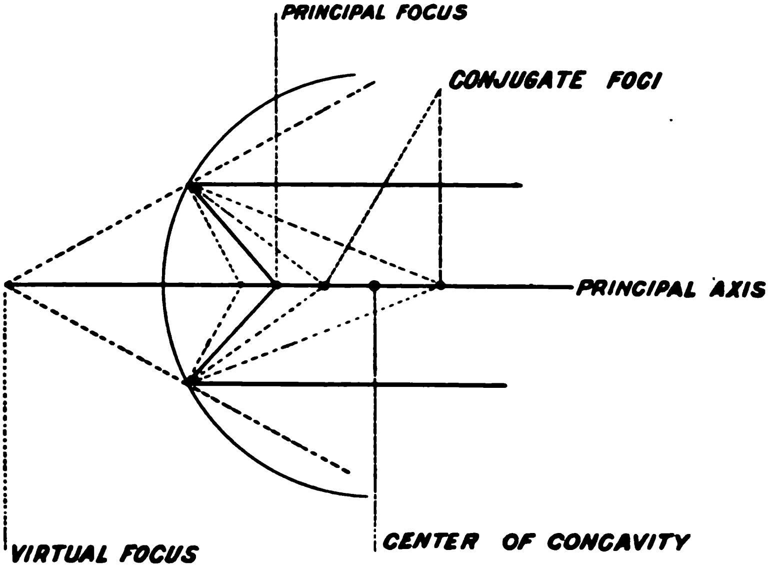

FIG. 168.

A concave surface reflects rays in a manner similar to that of a number of plane surfaces inclined towards one another. Parallel rays are caused to converge and meet at a point in front of the concave surface called the *principal focus.* A line drawn from the centre of concavity passing through the principal focus to the centre of curvature is known as the *principal axis.* The *focal length* of a concave surface or mirror is the distance from the mirror to the principal focus.

Rays which diverge from a point beyond the principal focus are reflected convergently, while those which diverge from a point inside of the principal focus are reflected divergently.

The image formed by a concave reflecting surface or mirror varies in size and characteristics, according to the distance between the object and the mirror. If a luminous point or object is placed between the mirror and its principal focus, an erect, virtual, and enlarged image will be formed, but if the object is between the principal focus and the centre of concavity an enlarged inverted image will result. An increase of the distance in the first instance causes enlargement of the erect image, while in the second instance the size of the inverted image decreases. There is no image formed if the object is placed at the principal focus, but if situated at the centre of curvature an inverted image of the same size will be produced. The placing of the object beyond the centre of concavity gives rise to a small inverted image.

Rotation of a concave reflecting surface or mirror from side to side causes an object placed within its principal focus to appear to move in the same direction as the mirror, but if the object is outside of the principal focus it appears to move in the opposite direction.

A convex reflecting surface causes parallel rays falling upon it to diverge, and hence never meet. If prolonged backward, such rays will meet at a point called the principal focus and will give rise to a negative image. The image formed by a convex mirror is always erect, virtual, and smaller than the object, and its position remains unchanged by tilting of the mirror. The closer the object is to the mirror the larger the image will be, and the more distant the object the smaller the image.

Refraction consists in the deviation of the rays from straight lines, owing to the different densities of the various media through which they pass. A ray of light striking a plane surface perpendicularly passes through the medium unaltered in its direction, being unaffected by the density of the medium. An oblique ray passing from a rare to a denser medium is refracted or bent towards a line perpendicular to the surface of the dense substance. Upon emerging from the dense medium the ray continues its course parallel to the original course it took before being refracted.

The index of refraction is the term applied in describing the comparative refractive power of different bodies, and may be obtained by dividing the *sine* of the angle of incidence by the *sine* of the angle of refraction, owing to the fixed ratio which exists

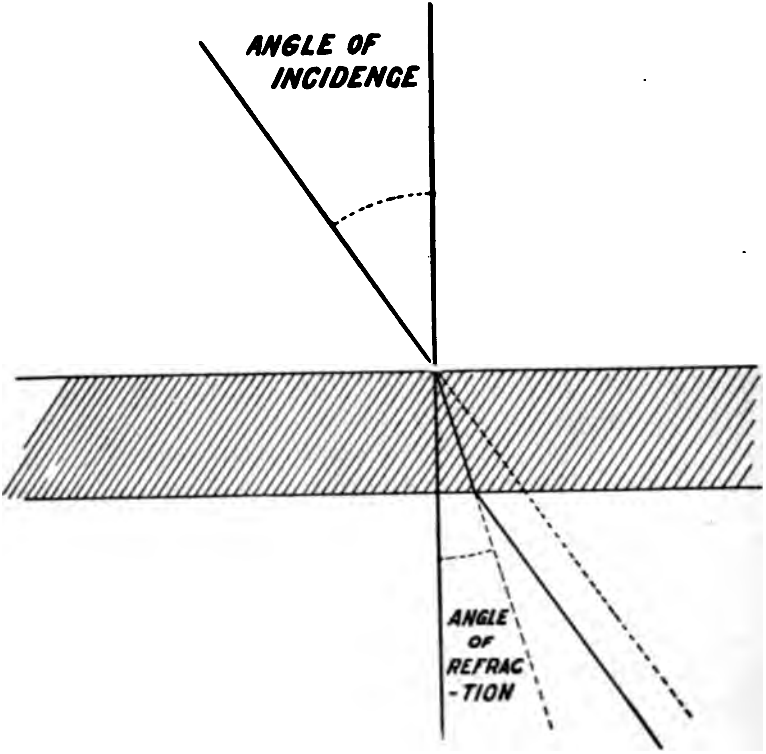

FIG. 169.

between them. The following table shows the range of the index of refraction in ordinary substances:

Air	1.00029
Water	1.3342
Ice	1.30
Cornea	1.3507
Aqueous humour	1.3420
Vitreous humour	1.3485
Crystalline lens	1.4541
Ordinary spectacle glass	1.53
Diamond	2.4
Cinnabar	3.20

A prism is any refracting substance in which two plane surfaces incline towards each other. The *apex* is formed by the convergence of the plane surfaces at one extremity, the **base** being formed by their divergence at the other extremity. *The refracting angle* of a prism is formed by the inclination of the plane surfaces towards each other as they converge to form the apex. The *angle of deviation* is the angle formed between the direction of the incident and emergent rays and shows the total deflection.

Rays of light entering or passing through a prism are always deflected towards its base in accordance with the fundamental law of refraction. The entering ray is bent towards the perpendicular of the first plane surface as it passes into the denser medium, and as it emerges into a rarer medium it is deflected from the perpendicular of the second plane surface.

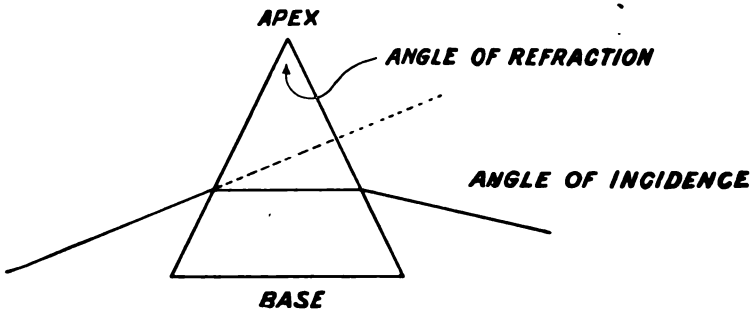

Fig. 170.

The position of a prism is always expressed by the situation of its base. Objects seen through a prism appear to be displaced towards the apex, and this fact is made use of in disorders of the ocular muscles. A prism has no focusing power and cannot form images. Parallel rays pass through unchanged in their relation to each other.

The strength of prisms may be expressed in degrees, in centrads, or in prism diopters. In the first, the value of the prism corresponds to the degree of the refracting angle; in the second, the centrad corresponds to the deviation, the arc of which is $\frac{1}{100}$ of the radius; in the third, the unit is the prism-diopter, which will deflect a ray of light 1 centimetre for each diopter of distance, the deviation being measured on the tangent. The difference between the systems in the lower numbers of prisms is so slight that for practical purposes it may be disregarded.

Neutralization of prisms is often necessary to determine the degree of prism contained in ordinary spectacle lenses. This may be easily performed by holding the prism, with the base toward the right, at 1 metre distance, over a series of numbered parallel lines separated by an interval of 1 centimetre, and noting the amount of displacement of the first line. Fig. 171.

Prisms are used to overcome the effects of paralysis and insufficiency of the ocular muscles, as a test for disturbance of muscle equilibrium, in ocular gymnastics, and to determine the presence or absence of monocular blindness in malingerers.

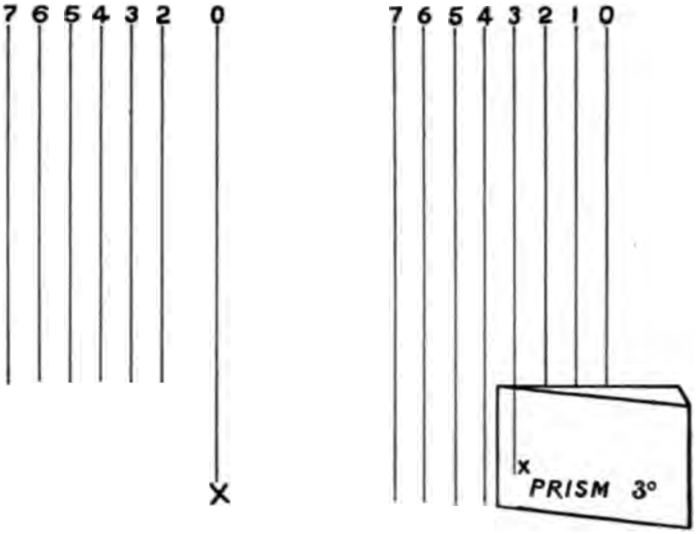

FIG. 171.

Lenses.—A lens is a piece of glass or other transparent substance, one surface of which at least must be curved. Lenses may be spherical or cylindrical.

Spherical lenses are those in which the curved surfaces are segments of spheres. They refract rays of light equally in all meridians, and are of two kinds, convex and concave.

A *convex spherical* lens may be considered as being made up of two prisms, the bases of which are placed in apposition, and hence has the power of converging parallel rays or bringing them to a focus. A convex lens may also be designated as a converging, magnifying, positive, or plus lens. It may be made in three forms: *Plano-convex,* in which one surface is plane and the other

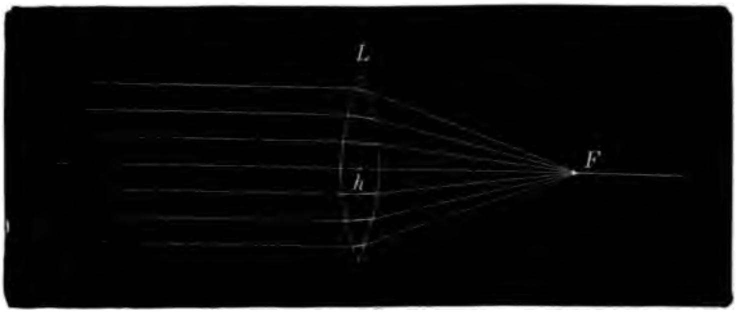

Fig. 172.—Union of Parallel Rays, effected by a Convex Lens.

curved; *biconvex,* having both surfaces curved convexly; or *concavo-convex,* in which there are two curved surfaces, one convex and the other concave.

Concave lenses are spherical lenses made up of prisms with the apices placed together. They render rays of light passing through them divergent, and are known as diverging, reducing, negative, or minus lenses. They may be *plano-concave,* one surface plane, the other curved concavely; *biconcave,* in which both surfaces are concave; or *convexo-concave,* having one convex and one concave surface.

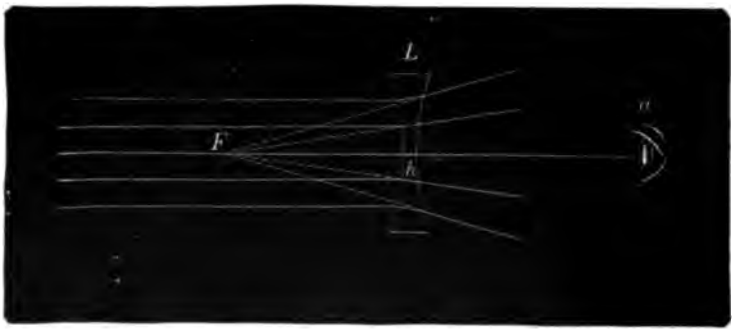

Fig. 173.—Dispersion of Parallel Rays by a Concave Lens.

Convexo-concave and concavo-convex lenses are also called periscopic or meniscus lenses. They serve to enlarge the visual field and prevent spherical aberration.

The *optical centre* of a spherical lens is also called the *nodal point,* and is a point where the secondary rays cross the principal axis.

The *principal axis* is a line passing through the optical centre perpendicular to the lens surfaces.

The *axial ray* is the ray that follows the course of the principal axis. It is not refracted.

The *focal length* of a lens is the distance from the optical centre to the principal focus.

The *principal focus* or shortest focus is a point on the axial ray or prolongation of the principal axis where parallel rays meet.

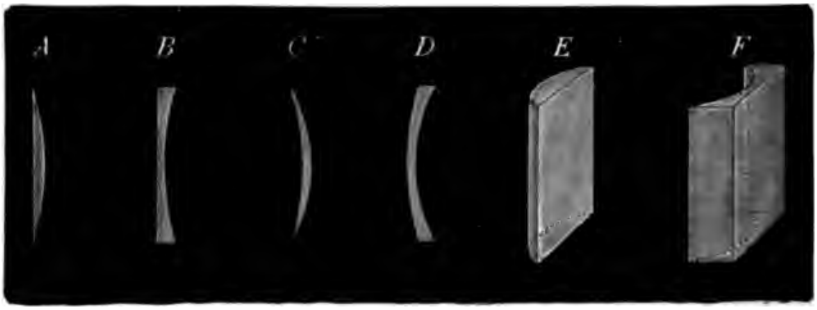

FIG. 174.

A, plano-convex lens; *B*, plano-concave lens; *C*, positive meniscus; *D*, negative meniscus; *E*, convex cylindrical lens; *F*, concave cylindrical lens.

Images formed by lenses result from a collection of foci, and may be real or virtual. A real image is formed by the actual meeting of the rays, and can be projected upon a screen. A virtual image results from prolongation backward of diverging rays until they meet. Such an image can be seen only by looking through the lens.

In convex lenses the relation in size between the image and object depends upon their respective distances from the optical centres. If the object is situated at the principal focus no image will be formed. The situation of the object between the principal focus and optical centre gives rise to an erect and virtual image larger in size than the object. If the object is just beyond the principal focus, the image will be real, inverted, and enlarged. If
]

the distance between the object and the optical centre is twice that of the principal focus, a real image, inverted, and of the same size as the object, will be formed. A greater increase of the distance will result in the image becoming smaller and inverted, but real.

In concave lenses the images are always virtual, erect, and smaller than the objects, and can be seen only by looking through the lenses.

Convex lenses are used to correct hyperopia; concave lenses are used to correct myopia.

Cylindrical Lenses.—A cylindrical lens may be considered as a segment of a cylinder having a plane surface at one axis and a concave or convex surface at right angles to this axis. The axis of a cylinder is that meridian which is parallel to the axis of the original cylinder and is indicated by a small scratch near the margin of the lens. A cylinder refracts rays of light passing through it only in the meridian at right angles to its axis. It has no one focal point, but has instead a line of foci parallel to its axis. Rays of light passing through cylinders are refracted in the same manner as in passing through other concave or convex media, but only in one meridian, that at right angles to the axis. Cylinders are used to correct astigmatism, and may be combined with concave or convex spherical lenses; such combinations are known as sphero-cylinders.

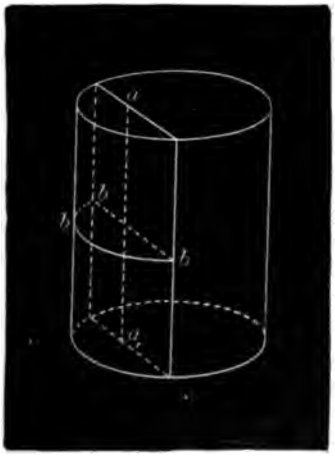

FIG. 175.—THE CONVEX CYLINDRICAL LENS CONSIDERED AS A SEGMENT OF A CYLINDER.

Numeration of Lenses.—This is based upon the refractive power or strength of the lens which is indicated by its principal focal distance. The strength of a lens varies inversely as its focal distance. It is most commonly expressed in the metric system, in which a lens having a focal distance of 1 metre is taken as a unit. This unit is known as the diopter. Lenses of greater or less strength than this are expressed in whole numbers or decimals. A lens of 2 diopters has a focal length of ½ metre, while a lens of 0.50 diopters has a focal length of 2 metres.

Neutralization of Lenses.—A spherical lens if held a short distance before the eye and moved in every direction will cause movement of the objects seen through the lens, with or against that of the lens, according as it is concave or convex. A lens of opposite power held before the lens under examination, which causes cessation of movement, indicates the strength of the lens. Concave and convex lenses of the same focal distance when held together neutralize each other and produce no movement of objects seen through them.

In cylindrical lenses the meridian in which there is no movement indicates the axis. The cylinder of opposite power which, placed at the same axis, causes cessation of the movement in the first cylinder, indicates its strength.

A lens measure may be employed to determine the strength of a lens, but requires taking of the curvature of both surfaces of the lens.

The *optical centre* of a lens should correspond to the geometrical centre, but often this is not the case, owing to the purposeful decentering of the lens. The centre may be easily ascertained by looking through the lens at two lines crossed at right angles. When the lens is so placed that the portions of the lines outside of the lens are directly continuous with those seen through the glass, the point where the lines cross will indicate the optical centre.

ABBREVIATIONS USED IN OPHTHALMOLOGY

Am.	Ametropia.
As.	Astigmatism.
H.a. or H.a.s.	Hyperopic astigmatism.
M.a. or M.a.s.	Myopic astigmatism.
C. or Cyl.	Cylinder.
D.	Diopter.
E. or Em.	Emmetropia.
H.	Hyperopia.
M.	Myopia.
M.A.	Metre.
O.D.	Oculus dexter (right eye).
O.S.	Oculus sinister (left eye).
O.U. or O_2.	Oculus utrique (both eyes).
P.p.	Punctum proximum (near point).

P.r.	Punctum remotum (far point).
Pr. or P.	Presbyopia.
S. or Sph.	Spherical lens.
T.	Tension.
V.	Vision.
+	Plus or convex.
—	Minus or concave.
=	Equal to.
○	Combined with.

PHYSIOLOGICAL OPTICS

Vision results from the interpretation in the brain of impulses produced by images thrown upon the retina. These images, when perfectly formed, are inverted and smaller than the objects from which they came, and stimulate the rods and cones of the retina, particularly in the macular region. Impulses are from thence sent to the visual areas in the brain along the optic tracts, resulting in the sense of sight. Imperfect formation of the images by the refracting media results in failure to properly stimulate the rods and cones, and blurring of vision is the consequence.

For purposes of study it is necessary to project a schematic eye which, when in a state of rest, will cause parallel rays entering it to be focused on the macula. Such an eye would have an antero-posterior diameter of 23 millimetres, and its nodal point or optical centre would be 7 millimetres back of the anterior surface of the cornea and 15 millimetres from the fovea.

Curvatures of a schematic eye:

Anterior surface of the cornea	7.8	millimetres
Posterior surface of the cornea	6.0	"
Anterior surface of the lens	10.0	"
Posterior surface of the lens	6.0	"

Indices of refraction of the transparent portions of a schematic eye:

Cornea	1.377
Aqueous	1.337
Lens	1.438
Vitreous	1.337

A schematic eye is a compound dioptric system having three refracting surfaces, the anterior surface of the cornea and the anterior and posterior surfaces of the lens, and three refracting media, the aqueous, the lens substance, and the vitreous. These surfaces and media are all centred on a line called the *optic axis*, which connects the centre of the cornea, the nodal point, and the posterior principal focus on the retina.

Although the refracting apparatus of a schematic eye forms a compound dioptric system, this compound system may be substituted by a single system composed of *six cardinal points* and *six planes*, the latter being situated at the cardinal points perpendicular to the optical axis. The cardinal points are: 2 principal points, 2 nodal points, and 2 principal foci. The planes bear corresponding names.

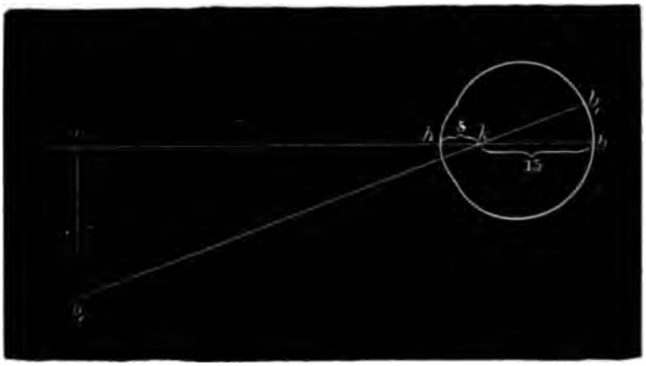

FIG 176.—REDUCED (SCHEMATIC) EYE OF DONDERS.

The location of the cardinal points is as follows:

First principal point, 1.8 millimetre behind the anterior surface of the cornea.

Second principal point, 2.1 millimetres behind the anterior surface of the cornea.

First nodal point, 7.1 millimetres behind the anterior surface of the cornea.

Second nodal point, 7.4 millimetres behind the anterior surface of the cornea.

Anterior principal focus, 14 millimetres in front of the cornea.

Posterior principal focus, 24 millimetres behind the anterior surface of the cornea.

The *principal points* are placed close together in the anterior chamber, and the relation between them is such that when an incidental ray passes through the first principal point the corresponding emergent ray will pass through the second principal point. The space between these points is so small that for ordinary purposes the points may be considered as one.

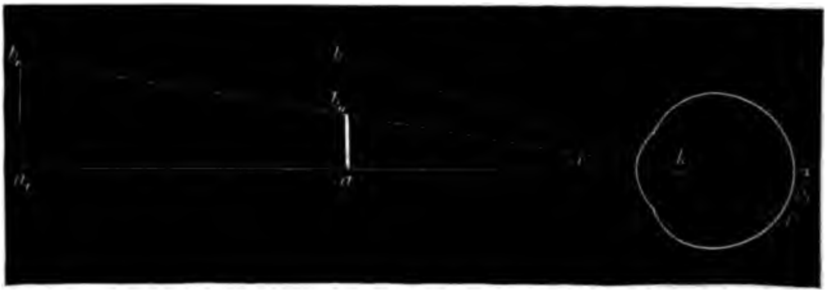

FIG. 177.—BEHAVIOUR OF THE VISUAL ANGLE WHEN OBJECTS VARY IN SIZE AND DISTANCE.

The *nodal points* are also placed close together, being so situated near the posterior pole of the lens; they correspond to the optical centre, and rays passing through them undergo no alteration.

The *first principal focus* is a point on the axis at which parallel rays from the vitreous meet, while the *second principal focus* is also a point on the axis situated between the macula and optic disk at which parallel rays meet after being refracted by the dioptric system of the eye.

The *centre of rotation* of the eyeball is situated in the vitreous about 10 millimetres in front of the retina.

The *visual angle* is the angle which rays of light from the extremities of an object subtend at the nodal point or optical centre. The apparent size of an object depends upon the extent of the visual angle. To determine the size of the retinal image it is necessary to multiply the size of the object by the distance of the nodal point from the retina. The product thus obtained is divided by the distance of the object from the nodal point, and the resulting quotient is the size of the retinal image.

The *visual line* is a line that extends from the object to the macula passing through the nodal point.

The *fixation line* joins the object with the centre of rotation, and frequently corresponds to the visual line.

The *angle gamma* is the angle formed by the optical axis with the fixation line and varies with the refraction of the eye. In the emmetropic eye it is about 5 degrees; it increases in hyperopia and decreases in myopia.

The *angle alpha* is formed by the long axis of the corneal ellipse and the visual line.

Emmetropia is a condition of refraction of the eye in which parallel rays from a distance of 6 metres are focused on the macula when the eye is in a state of rest. This condition is present in the schematic eye already described.

Ametropia is a more frequent condition of refraction in human eyes, and is due to the formation of images elsewhere than on the retina. It includes *hyperopia*, *myopia*, and *astigmatism*. *Hyperopia* is a condition in which the rays are focused behind the retina, while in *myopia* the focus occurs in front of the retina. In *astigmatism* the rays are differently refracted in the various meridians, giving rise to a blurred image.

Accommodation.—The arrangement of the dioptric mechanism of a schematic eye provides only for the focusing of parallel rays of light from a distance of 6 or more metres; any object placed at a closer range would be focused behind the retina, giving rise to a blurred image unless the visual angle was of the same degree as that of some standard object at 6 metres distance. In the human eye provision is made for altering the refraction, so that

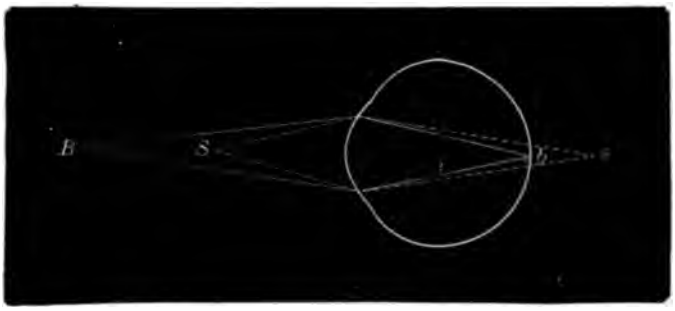

FIG. 178.

The eye being focused for a certain distance, *B*, rays emanating from a nearer point, *S*, form a diffusion circle upon the retina.

objects at close range as well as those at a distance may be clearly perceived. The phenomena attending this alteration constitute accommodation.

In any optical apparatus, such as a camera, this change of focus is accomplished by increasing the distance from the lens to the part corresponding to the retina, but in the eye it is brought about by an additional refractive power in the lens. This may easily be proved by the images which a lighted candle throws upon the anterior surface of the cornea, upon the anterior capsule of the lens, and upon the posterior capsule of the lens. During accommodation the image upon the anterior capsule of the lens diminishes in size and approaches that upon the anterior surface of the cornea.

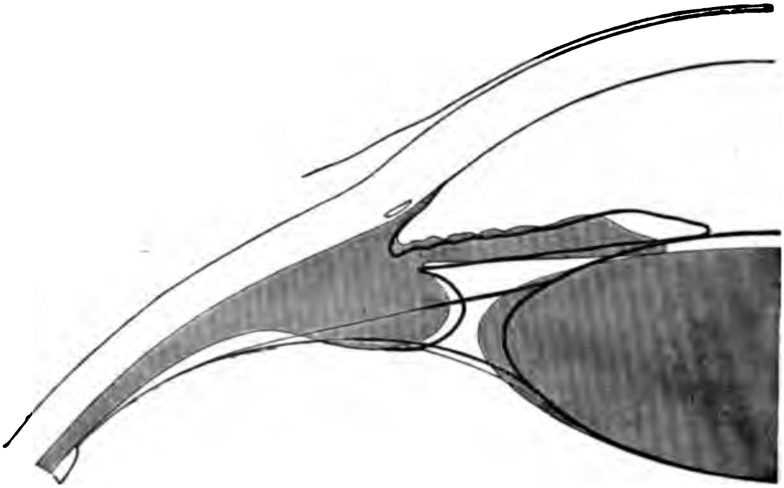

FIG. 179.—SCHEMATIC REPRESENTATION OF THE PROCESS OF ACCOMMODATION.

The relation of the parts when the accommodation is at rest is designated by the shaded portions, and the relation when there is an effort of accommodation by the black line. The latter shows the ciliary processes and also the equator of the lens pushed towards the axis of the eye. Both surfaces of the lens are more curved and the anterior surface is advanced. The iris is broader, and at its pupillary border is displaced forward; at its ciliary border backward.

Accommodation results from contraction of the ciliary muscle, which is attended by relaxation of the suspensory ligament of the lens. Following this relaxation the lens bulges forward by reason of the elasticity of its fibres. As age advances, the lens loses its elasticity and the function of accommodation is diminished to a corresponding degree. The volume of the lens is not increased during accommodation, the antero-posterior diameter being increased at the expense of the lateral diameter. Coincidently with the change in the convexity of the lens there is contraction of the pupil, the anterior chamber becomes shallow, and in binocular vision there is convergence of the visual lines.

The *far point,* or punctum remotum, is the point at which distant objects can be distinctly seen by an eye in a state of complete rest. Infinity is the far point of an emmetropic eye.

The *near point,* or punctum proximum, is the nearest point at which objects can be seen by an eye during full accommodation. It may easily be ascertained by determining the shortest distance at which the smallest Snellen type on a reading card can be seen.

The *range of accommodation* is the distance between the far point and the near point.

The *amplitude of accommodation* is the difference in the refraction of the eye when in a state of complete rest and when in a condition of maximum refraction. The strength of the lens necessary to take the place of accommodation when placed before the eye represents the amplitude or power of accommodation. The amplitude of accommodation may be easily determined by dividing the distance of the near point, taken in centimetres, by 100. This rule is applicable in emmetropia.

The amplitude of accommodation decreases and the near point recedes as age increases, owing to diminution of the elasticity of the lens. After the age of forty-five years this condition is very frequent, and is known as presbyopia. The following table illustrates the influences of age upon accommodation:

Year.	Near point.	Amplitude in diopters.	Year.	Near point.	Amplitude in diopters.
10	7.0 cm.	14.0	45	28.0 cm.	3.5
15	8.5 "	12.0	50	40.0 "	2.5
20	10.0 "	10.0	55	55.0 "	1.75
25	12.0 "	8.5	60	100.0 "	1.0
30	14.0 "	7.0	65	133.0 "	0.75
35	18.0 "	5.5	70	400.0 "	0.25
40	22.0 "	4.5			

The full power of accommodation is seldom utilized, as about one-third is held in reserve to permit the continuous performance of near work without distress.

In hyperopia a certain amount of accommodation is used to correct distant vision, so that the near point with the same amplitude of accommodation is farther away than emmetropia. This constant strain upon the ciliary muscle tends to hasten presbyopia.

In myopia the near point is closer than in emmetropia for the same age. This allows the power of the ciliary muscle to be held in reserve, so that presbyopia is somewhat retarded.

Convergence.—In monocular vision the phenomena of accommodation occur without any change in the direction of the visual lines, but in binocular vision it is necessary for the visual axes to be directed towards each other or converged for the perfect perception of near objects. At a distance of 6 metres the visual lines may be considered as parallel, but as the object approaches the eye the convergence increases. It usually bears a harmonious relation to accommodation, but may occur independently, as when mydriasis is present.

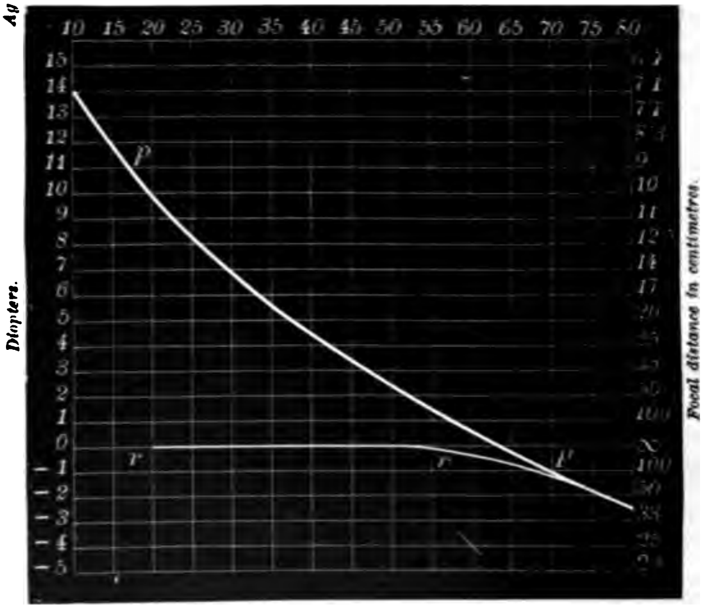

FIG. 180.—RANGE OF ACCOMMODATION AT DIFFERENT AGES. (After Donders.)

The *angle of convergence* is the angle which the visual line makes in turning from distant to near objects. The unit is the metre angle, which is the angle formed by the visual line with the median line when the eyes are directed towards an object at 1 metre distance. The degree of convergence may be easily ascertained by placing prisms of varying strengths before the eyes.

The relation between accommodation and convergence is such that 1 degree or metre angle of convergence is necessary for every diopter of accommodation in the emmetropic eye.

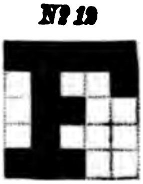

FIG. 181.—A LETTER FROM SNELLEN'S TEST CARD.

Negative convergence is present when the visual lines are parallel; *positive convergence* exists when there is any inward deviation of the visual lines.

Relative accommodation is the power of altering the accommodation without changing the convergence.

Visual Acuity.—In all diseased conditions of the eye it is important to determine the acuteness of vision, as in this manner the degree of functional impairment is ascertained. The essentials for distinct vision are clear media, regularity of the refracting curvatures, and the perfect collection or focusing of the rays of light upon the maculæ of both eyes.

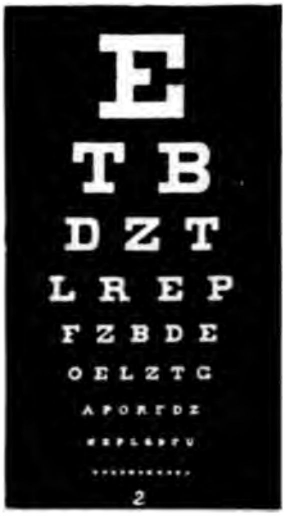

FIG. 182.—TEST CARD.

The macular region is the most sensitive portion of the retina to light. The cones which are the essential elements to visual perception are about 60 in number at this point, each being 3 micromillimetres in size and having an interval of but 0.002 millimetres between them. In order that an object may be distinctly seen, it has been ascertained that it must subtend an angle of at least one minute or be 4 micromillimetres in size.

The methods employed for the determination of the acuity of vision make use of this fact in the construction of test letters, each limb of which subtends an angle of one minute, and the whole letter subtends to an angle of 5 minutes. Snellen's types are so constructed and are most commonly employed for ascertaining the acuteness of vision. The letters may be white upon a black background or black upon a white background. For use among illiterate people a card upon which a number of E-shaped figures are printed is used. These figures are of various sizes in accordance with the Snellen principle and point in different directions; the patient is requested to show the direction in which the limbs of the figures point. Cards with letters reversed are also constructed for use in small rooms, where with the aid of a plane mirror the proper distance can be obtained. These letters, however, subtend an angle of but four minutes.

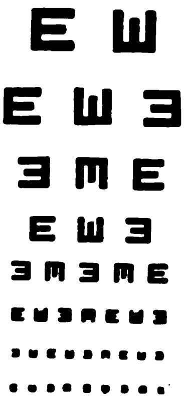

FIG. 183.—ILLITERATE CARD.

To determine the visual acuity the patient should be seated about 6 metres from the test-card, and each eye should be tested separately. He is then asked to call out the letters or show their direction (if illiterate) as far down the card as he is able. As each line of the test letters is arranged for a certain distance, a number denoting this distance is placed at one side of the letters. The degree of acuteness of vision is then expressed by a fraction in which the numerator is the distance from the patient to the test-card and the denominator is the number of the lowest line on the card read by the patient. For instance, if a patient at a distance of 6 metres reads the line of letters marked 6, his vision will be $\frac{6}{6}$ of normal.

If the vision is reduced to such an extent that reading of letters at any distance is impossible, the distance at which the movement of fingers can be perceived, or the noting of them can be performed, should be taken. A further reduction of vision necessitates ascertaining whether reflected light can or cannot be perceived, together with locating its source.

For determining the near point, reading cards are made upon which smaller Snellen type are printed. The near vision is expressed in the same manner as the distant vision.

To determine the presence of any error of refraction, concave, convex, and cylindrical lenses should be placed before the eye at different times; the lens which increases the visual acuity indicates the kind of error present.

ERRORS OF REFRACTION

The normal state of the eye as regards its refraction is known as *emmetropia,* and an emmetropic eye focuses the image of distant objects exactly upon the macula lutea. Any departure from this condition that results in imperfect or blurred images constitutes *ametropia.* In addition to blurring of vision, ametropia is accompanied by various symptoms referable to eye-strain. *Asthenopia* is the term applied to this group of symptoms. Ametropia is of three varieties: *hyperopia, myopia, and astigmatism.*

Hyperopia is a form of ametropia in which the length of the eyeball does not correspond to the focal length of the dioptric system of the eye, and in which the principal focus, therefore, lies behind the retina. It may be due to the eyeball being shorter than normal, unusual curvature of the cornea or lens, or an increase in the density of the refracting media.

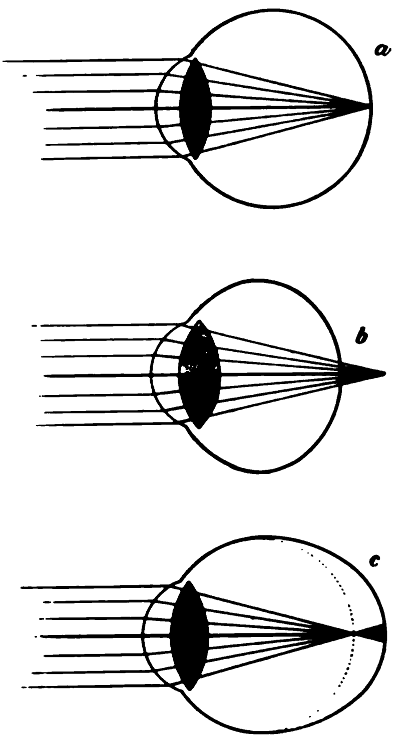

FIG. 184.—ERRORS OF REFRACTION.
a, emmetropia; *b,* hyperopia; *c,* myopia.

Hyperopia is nearly always a congenital defect, most children being born far-sighted. As the child grows, the eyeball elongates proportionately and emmetropia soon follows. Sometimes by reason of excessive near work myopia supervenes. As age advances—that is to say, after forty-five years—hyperopia again asserts itself. It is also present to a marked degree in eyes from which the lens has been extracted, as in cataract.

In a state of rest the hyperopic eye is able to focus rays from a distance that are already convergent. With the aid of an ordinary degree of accommodative power the near point will be found to have receded and close vision will be blurred. By an excessive amount of accommodation the distance vision may be brought to normal, together with improvement of close vision at the proper near point. The increase of work placed upon the ciliary muscle causes hypertrophy of its circular fibres, and consequently the ciliary muscle forms an obtuse angle with the iris. By reason of the abnormal functional activity of the ciliary muscle, failure of accommodation is often hastened, resulting in presbyopia at an earlier age than in emmetropia.

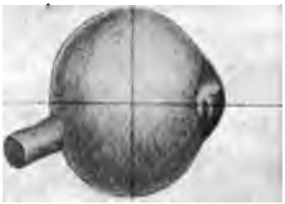
FIG. 185.—HYPEROPIC EYE.

In uncorrected hyperopia, convergence increases with the increase of accommodation by reason of the relation existing between them, so that internal strabismus or squint is often seen as a consequence. This is at first well marked only for near points, but later becomes manifest for distance as well.

The hyperopic eye, as ordinarily seen, presents certain characteristics which serve to distinguish it. The orbit in which it is contained is always more shallow than normal, and the length of the eyeball is less than in emmetropia. There is always a sharp curvature at the equator of the globe and the sclera is unusually thick. The anterior chamber is shallow and the pupils are small. The overgrowth of the circular fibres of the ciliary muscle is a constant accompaniment in uncorrected hyperopia of long duration.

Hyperopia may be of two varieties: *latent,* in which the error of refraction is overcome and disguised by the action of the ciliary muscle, and *manifest,* in which the refraction defect is uncorrected by accommodation. These varieties usually exist more or less combined.

In manifest hyperopia the vision for distance and near is indistinct, and more or less pain in the eyes and head is present. Three forms of manifest hyperopia have been described, *facultative, relative,* and *absolute.* Facultative hyperopia is that form in which an extra effect of accommodation may conceal the error without causing squint. Relative hyperopia requires undue convergence with the extra accommodative effect to overcome it, and internal strabismus or squint follows. Absolute hyperopia is that variety in which the accommodation has no effect.

Symptoms.—The manifestations of hyperopia are great in number, and are mostly referred to the excessive strain upon the ciliary muscle. The vision for objects at close range is nearly always blurred, or becomes so in a very short time. Reading of small print quickly tires the eyes and gives rise to drowsiness. The lids become heavy, and the eyes ache and burn if the near work is continued. In order to see more distinctly, affected persons hold their reading material very close to the eyes in a strong light. This causes the pupils to become contracted and the fissure between the lids (*palpebral fissure*) becomes narrow. Headache is frequent, and is usually frontal, but may be situated elsewhere. Neuralgia of the face or head may also occur as the result of eye-strain.

The continuous contraction of the ciliary muscle invites an increased amount of blood to the eye, causing congestion of the various portions of the eye. The optic disk becomes hyperæmic, the retina is hazy, and the chorioid is congested and granular in aggravated cases. The eyelids are red and feel heavy, and congestion of the conjunctiva is present. The vascular spaces of the iris are overfilled by the almost constant contraction of the pupil, as is shown by the slight ciliary injection. This general congestion of the eyeball tends to prolong and exaggerate any existing inflammation of any portion of the eye, or may act as a causal factor in its production.

In instances where the hyperopia is overcome without much congestive or visual disturbance it frequently happens that the excessive work of the ciliary muscle is manifested through the nervous system by various neurotic symptoms. Among these may be mentioned photophobia, headache, twitching of the lids, nausea, vertigo, vomiting, etc.

To correct hyperopia it is necessary to place before the eye a convex lens having its principal focus at the far point of the hyperopic eye. The strength of such a lens will be equal to the extra amount of accommodation required to neutralize the refraction error. The lens which neutralizes hyperopia is the highest convex lens that gives greatest visual acuity for objects at 6 metres distance from the eye. The effect of a convex glass increases as the distance between the eye and the glass is increased when the eye is directed towards distant objects, but in reading the strength of the glass diminishes as it is carried away. The correcting lenses should be worn constantly.

Ordinarily, a hyperopic person will accept a convex glass in testing for errors of refraction, but sometimes will prefer a concave lens. The apparent myopia in such cases is due to the ciliary muscle overcorrecting the hyperopia. This condition is most frequent in healthy young adults, and requires paralysis of their accommodation by some suitable drug during the examination. Spasm of accommodation in such individuals may simulate very grave affections, such as glaucoma. The use of the ophthalmoscope and retinoscope in the correction of hyperopia will be discussed later under separate headings.

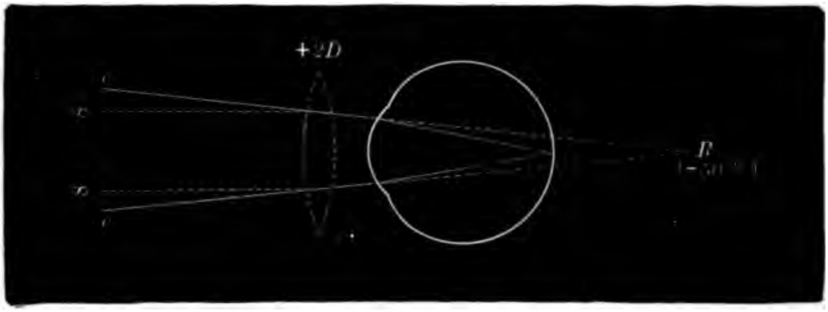

FIG. 186.—CORRECTION OF HYPEROPIA BY A CONVEX LENS.

Myopia is a state of refraction in which parallel rays entering the eye are focused in front of the retina. By the crossing of these rays in the vitreous, and their subsequent divergence, diffusion circles are formed, causing the images of objects at 6 metres distance or more to be blurred and indistinct. The myopic eye, on account of its length and excess of refractive power, is only capable of bringing to a focus divergent rays from some point closer than 6 metres.

The length of the eyeball in myopia is greater than that of an emmetropic eyeball, so that the macula always lies posterior to the principal focus of the dioptric system. The rays of light which pass out of the eye from the fovea become convergent and meet at some point inside of infinity.

The range of distinct vision is always less than normal, the near and far points of the eye being closer to the eye than in emmetropia. Near work can be performed without the aid of accommodation, and results in insufficiency of convergence which may be followed by external squint. In low degrees of myopia the accommodation is often quite active and may exaggerate the near-sightedness. Usually, however, the accommodative power is small, the circular fibres of the ciliary muscle are not prominent, while the longitudinal fibres are somewhat hypertrophied. This disuse of the ciliary muscle has one advantage: it retards presbyopia.

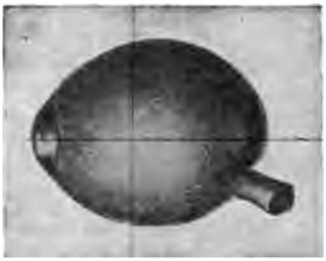

FIG. 187.—MYOPIC EYE.

The placing of a concave lens before a myopic eye causes the rays of light to diverge, and a clear image is formed by their focus on the retina.

The similar use of a convex lens causes increased convergence of the rays with a corresponding increase of the myopia.

Causes.—Myopia may be due to increased refraction of the dioptric system or increased length of the optical axis. The increased refraction may be caused by changes in the corneal curvature, as seen in conical cornea and staphyloma, by swelling of the lens, as in incipient cataract, giving rise to the so-called "second sight," and by increased curvature of the lens following spasm of the ciliary muscle, and diseases, such as cyclitis and irido-cyclitis, which cause relaxation of the suspensory ligament of the lens. The ordinary myopia is usually due to an abnormal length of the eyeball.

The cause of the elongation of the eyeball in myopia has been the subject of considerable discussion, resulting in the acceptance of three theories:

1. *The anatomical theory,* which holds that the eyeballs elongate by reason of the large size and peculiar shape of the orbits. No resistance is afforded the growth of the eyes.

2. *The mechanical theory,* which ascribes the length of the eye to compression between the external recti muscles and the orbit by the excessive convergence necessary to perform work at close distance. The lateral pressure causes the coats of the eyeball to

be distended backward because the resistance is least at the posterior pole.

3. *The inflammatory theory,* in which the cause is believed to reside in a low grade of inflammation of the ocular tunics, most marked at the posterior pole of the eye. Macular chorioiditis is a form of this inflammation. The inflammation is usually preceded by congestion of the retina and chorioid as the result of excessive and improper use of the eyes. The inflammation slowly supervenes, but never becomes active. Myopia in growing children is undoubtedly due to this cause. At birth, hyperopia is the rule and emmetropia follows with the subsequent growth. If the child is made to perform excessive near work under bad conditions, such as poor light, improper ventilation, imperfect posture, etc., congestion of the eyeball occurs posteriorly and becomes constant, soon passing into inflammation. The hygiene of the child, if improper, is a factor of great importance in the production of myopia. The infectious fevers often cause a change in the refraction of children's eyes, but this is probably due to the too early resumption of close work during convalescence. During this period the tunics are weak and easily distended by moderate strain.

The clinical forms of myopia are static, functional, progressive, and malignant myopia. *Static* or *true myopia* is the term applied to the ordinary variety due to elongation of the axis of the eye. *Functional myopia* is due to spasm of the ciliary muscle, conical cornea, swelling of lens as in incipient cataract, etc. *Progressive myopia* is that form in which the error increases progressively from year to year accompanied by destructive changes in the chorioid and other parts of the eye and by marked impairment of vision. *Malignant myopia* is progressive myopia when it runs a rapid course ending in blindness.

Symptoms.—One of the most marked symptoms of myopia is the blurring of distant vision, which gives rise to a false estimation of the magnitude and distance of objects. The interpretation of perceptions is always delayed. On account of the near point being closer than normal the patient is compelled to hold reading materials or other close work very near to the face, the head moving from side to side in following each line. Pain over the eyes, photophobia, photopsia, metamorphopsia, etc., may be present as structural changes in the coats of the eye advance.

Headache and reflex phenomena are uncommon in myopia uncomplicated by astigmatism on account of the very small amount of work placed upon the ciliary muscle.

The expression of a myopic individual is peculiar and characteristic. The face is broad and gives the patient the appearance of being stupid. The eyeballs protrude and the interpupillary space is wider than normal. The pupils are dilated, the anterior chamber is deep, and the lids are squeezed together over the eye to cut out the excess of light.

Myopia is a disadvantage at all times because the patient is unable to engage in outdoor games or pursuits without wearing glasses. This is followed by a tendency to perform an undue amount of close work, which has a bad effect upon the existing myopia. Persons who perform intellectual work are the most common subjects of myopia, but it is also frequent among the tailors, particularly of the lower class of Jews, who are compelled to perform considerable work in constrained positions under poor light. Violent exercise or work in myopes may be followed by chorioiditis, detachment of the retina, or rupture of the chorioid. There are but two advantages of myopia: presbyopia is retarded and glaucoma is infrequent.

Fundus Changes.—Examination of the myopic eye by means of the ophthalmoscope nearly always shows thinning of the chorioid and sclera. The chorioid seems to be drawn to the temporal side of the disk, producing a crescentic space of whitish or grayish colour at the outer side of the nerve-head. This crescentic patch is known as the conus or myopic crescent, and is due to the sclera showing through the atrophied chorioid. The head of the optic nerve is not infrequently distorted to correspond to this apparent distortion of the chorioid. Sometimes true myopia is preceded by a curvilinear reflex at the nasal side of the disk, and when seen may aid in the early recognition of the condition.

In high-grade myopia the tunics are so diseased that the lateral pressure of the muscles causes the atrophied chorioid and thinned sclera to bulge posteriorly in the region of the optic nerve, giving rise to posterior staphyloma. Patches of atrophied chorioid, with sclera showing through, and pigmentary changes may be scattered throughout the whole eye-ground. The vitreous soon becomes semi-fluid and floating bodies are found in it. The retina will become detached if the myopia progresses, and opacities of the lens will often follow. The vision fails according to the degree of structural change in the macular region.

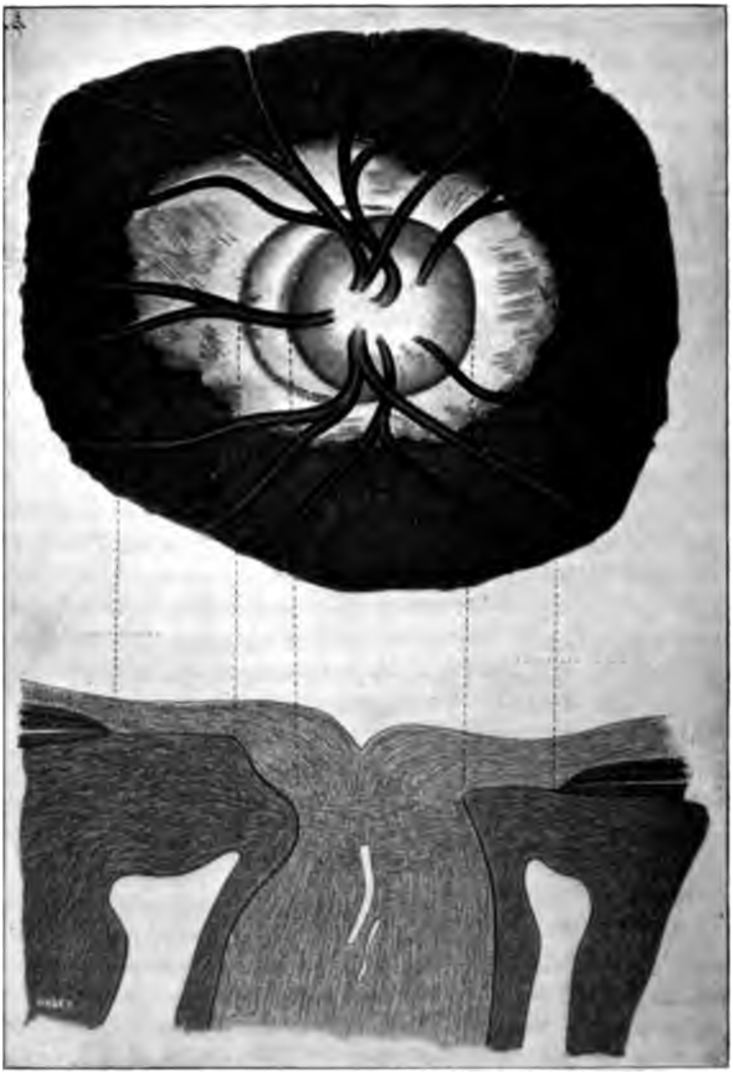

FIG. 188.—POSTERIOR STAPHYLOMA. MYOPIC EYE. (Magnus.)

The *diagnosis of myopia* is made by the acceptation of a concave lens by the patient under the influence of a mydriatic, with improvement of distance vision. The retinoscope and ophthalmoscope may be employed as confirmatory tests.

The *prognosis* in low forms of the condition is very favourable, provided the treatment is prompt and carefully conducted. Progressive myopia is always a serious condition, and often advances in spite of the best treatment. Malignant myopia is a hopeless affection. Myopia in children and young adults is more serious than in persons past thirty years of age, as the condition usually becomes stationary at this time.

The *treatment* consists in wearing the weakest concave lens which gives best distance vision and which corresponds to the far point, together with reducing the amount of near work, and employing appropriate measures for preventing the disease's progress.

To obtain the strength of the correcting lens, the eyes should be examined while under the influence of a mydriatic, otherwise too strong a glass will be accepted. In low degrees the full correction should be worn constantly. If over 4 diopters of myopia are present, full correction is necessary for distance only, while for near a reduction is made, so that reading material can be held at a distance of about 13 inches from the eye. In presbyopia it is necessary to add convex lenses to the myopic correction to afford comfortable reading. If there is much divergence, prisms should be ordered or the lenses should be decentred. In divergence of more than 10 degrees some muscle operation should be performed.

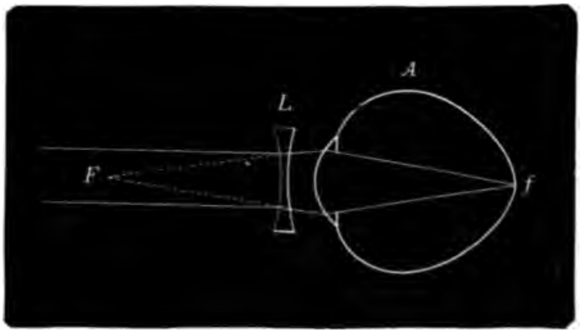

Fig. 189.—Correction of Myopia by a Concave Glass.

The preventive measures in the treatment of myopia consist largely in rendering the near work less injurious. When symptoms are pronounced, it should be temporarily suspended. It is necessary at all times to keep growing children in the best of health, so that their eyes will be in condition to resist the ordinary strain placed upon them. During convalescence of the infectious fevers or other illness the child should not be allowed to read, write, or study except very moderately. Fresh air, tonics, good food, outdoor exercise, etc., are necessary at this period to restore tone to the weakened physical condition.

School children should be carefully watched; the first signs of failing vision necessitate the consulting of an oculist. The light of the school-room should enter from two sides, preferably the north and the east. The pupil sits facing the east while the light falls on the left side of the book or slate. Not less than 1 square foot of window glass should be allowed for 5 square feet of floor space. The ceilings and walls should be dull white in colour, and adjoining buildings which encroach on the light space should also be painted white.

The desks should be sloping and of sufficient height to prevent undue stooping over. A highly polished desk surface is harmful in that it causes considerable reflection. The chairs should allow the feet to touch the floor.

The books used by the scholars should be printed upon unglazed paper; the type should be broad-faced and the ink black.

Astigmatism is a form of ametropia in which rays of light entering the eye are refracted differently in the various meridians. It bears no relation to the length of the eye. The meridian of greatest refraction and that of least refraction are known as the two principal meridians and are at right angles to each other.

A small degree of astigmatism exists in every eye due to irregularities in the curvature of the lens or cornea, or both. Frequently the lenticular astigmatism neutralizes that of the cornea and thus evades detection. The extra-ocular muscles is exercising their function also produce a physiological form of astigmatism.

The condition seldom exists alone, but is usually combined with myopia or hyperopia. It is most frequently a congenital defect, but may be acquired by injury or disease of the eyeball. An excess or diminution of orbital fat aids in changing the curvature of the eyeball, but more commonly it is due to ulcers or wounds of the cornea. The scars following ulcers or wounds while undergoing absorption produce astigmatism, which varies in degree as absorption progresses. This is best seen after the removal of a pterygium encroaching on the cornea and after cataract operations. The pressure of swollen eyelids or a chalazion gives rise to a temporary astigmatism which disappears as the cause is removed. Swelling of the lens is also a factor in its production. Operations upon the extra-ocular muscles are followed by astigmatism on account of the disturbance of pressure thus produced. Astigmatism may also be produced voluntarily by pressure upon the eyeball with the finger.

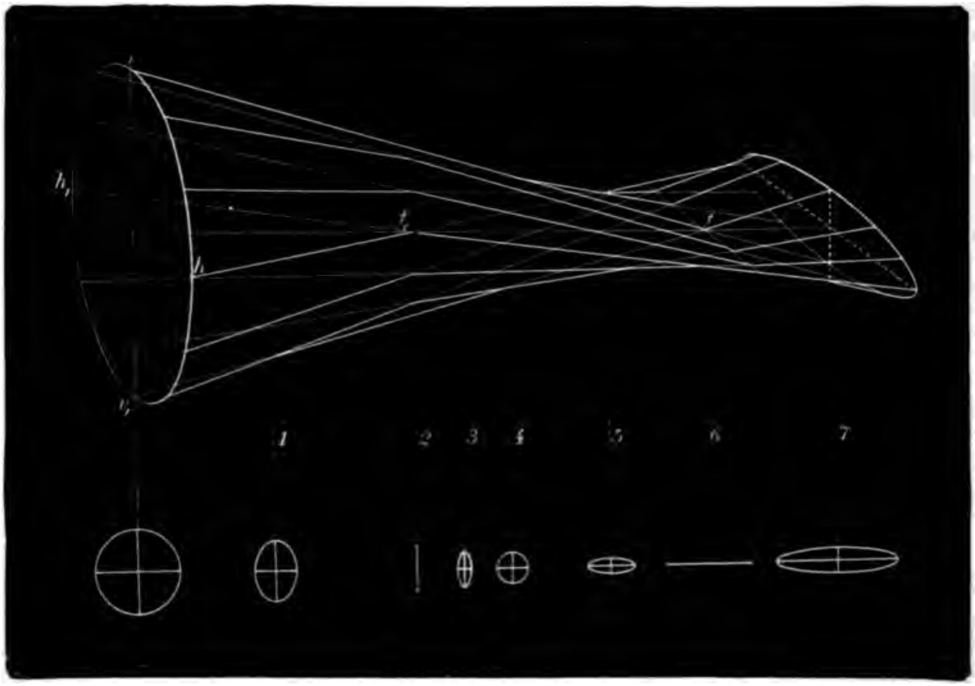

Fig. 190.—Refraction of the Rays in Regular Astigmatism.

There are two principal varieties of astigmatism, regular and irregular.

Irregular astigmatism consists in variations in refraction along the course of one or more meridians. Different parts of the same meridian have different refractive powers, and blurred images are formed that cannot be improved by glasses. It is usually due to some pathological change in the cornea or lens.

Regular astigmatism is that form in which there is a difference in the refraction of the principal meridians. It is the most common variety.

Parallel rays passing through a spherical surface form a circular cone and are brought to a focus at a point, but in astigmatism, owing to the principal meridians having their principal foci at different points, the resulting cone will be oval and the images will be more or less elongated. This is best shown by having an astigmatic individual look at two lines crossed at right angles. The vertical line is refracted through the horizontal meridian and the horizontal line through the vertical meridian. If one meridian is curved more than the other, the line seen through this meridian will be blurred and indistinct, and the lines parallel to the ametropic meridian will be seen most clearly.

Regular astigmatism may be subdivided into simple, compound, and mixed. *Simple astigmatism* is present when one principal meridian is emmetropic and the other is hyperopic or myopic. *Compound astigmatism* is the form in which both principal meridians are myopic or hyperopic, but of different degrees. *Mixed astigmatism* consists of hyperopia in one meridian with myopia in the meridian at right angles to the first.

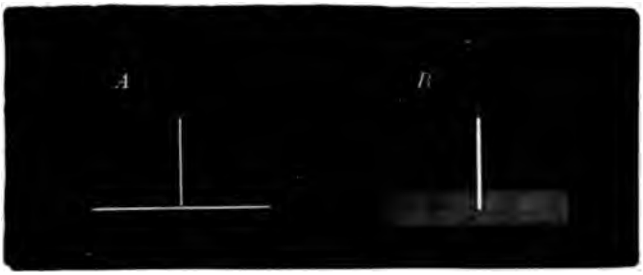

FIG 191.—RETINAL IMAGES IN REGULAR ASTIGMATISM.

A, two lines placed perpendicular to each other; *B*, their image upon the retina of an astigmatic person.

Regular astigmatism may also be symmetrical or asymmetrical. When the combined values in degrees of the axes of astigmatism in both eyes equal 180 the astigmatism is said to be ***symmetrical***. Any departure from this constitutes ***asymmetrical*** astigmatism.

Astigmatism with the rule refers to those cases in which in hyperopia the axis of the cylinder is at 90 and in myopia the axis is at 180. A reversal of this is known as *astigmatism against the rule.*

The *symptoms* produced by astigmatism, even in very low degrees, are well marked and characteristic of eye-strain. The vision is indistinct for distance and near, letters are always miscalled, and reading is difficult on account of the blurring of the type and running together of the lines. Headache, pains in the eyes, and various forms of neuralgia are often present. Drowsiness, congestion of the conjunctiva, inflammation of the margins of the lids are also manifestations of astigmatism. In delicate persons of neurotic temperaments various reflex disorders may occur, which are relieved only by the wearing of cylindrical lenses. Nausea, indigestion, anorexia, etc., are frequent, and the patient often inclines the head towards one side in reading. The examination of the fundus always shows distortion of the head of the optic nerve and blurring of the vessels in a direction corresponding to the meridian of least refraction.

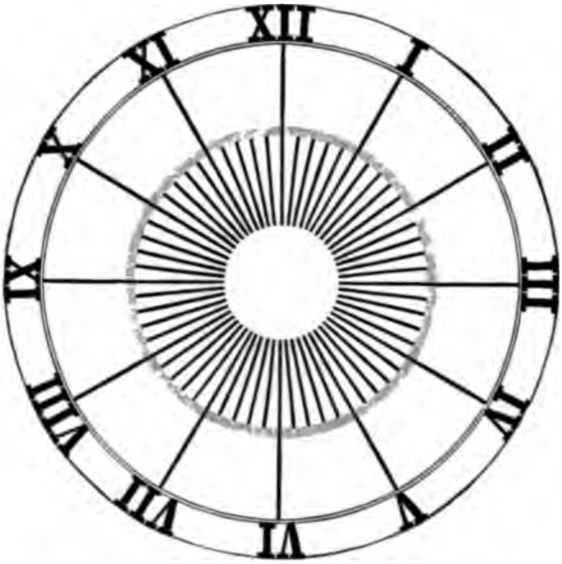

FIG. 192.—ASTIGMATIC DIAL.

Astigmatism should always be considered when the application of spherical lenses fails to increase the vision, but no tests are satisfactory unless the eye is placed at rest under the influence of a cycloplegic.

The *astigmatic dial* in which straight lines radiate from a centre and are numbered at the periphery, similar to a clock dial, is of great value in determining astigmatism. The lines most clearly seen correspond to the meridian of greatest refraction. The amount of astigmatism is indicated by the cylindrical lens placed before the eye with its axis at right angles to the lines most distinctly seen, which causes all the lines to be seen with equal clear-

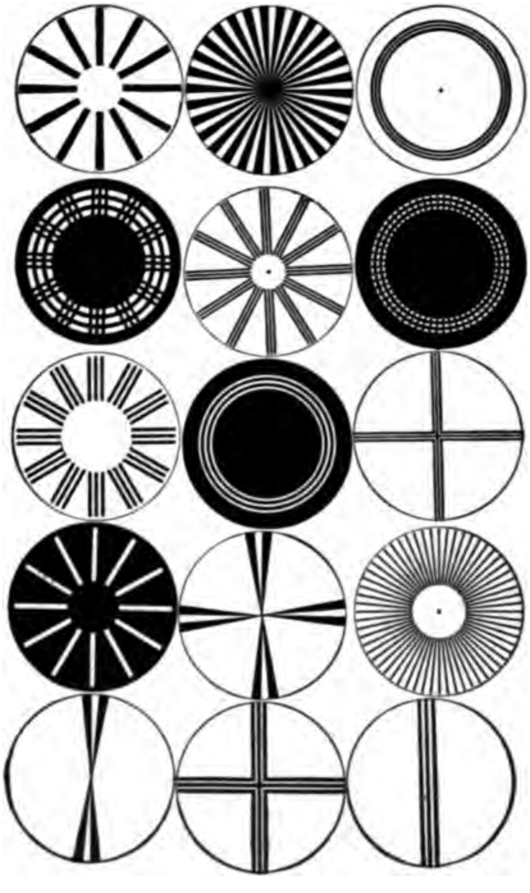

FIG. 198.—DR. GREEN'S ASTIGMATIC CHART. (Thorington.)

ness. The test letters of Dr. Pray are made up of lines inclined at various angles and are used in a similar manner.

The *stenopæic slit* consists of a metal disk with a slit in one of its diameters. As in all examinations for ametropia, the patient is seated at a distance of 6 metres from the test-card and the slit is inserted in the trial frame, each eye being tested separately. The slit is then rotated until the letters are most distinctly seen. This position of the slit indicates the meridian of least refraction. The vision should then be improved by lenses until normal. The slit is again rotated until at right angles to the first position. This is the meridian of greatest refraction, and should also be corrected until the vision is normal. The refraction of the first meridian indicates the strength of the spherical lens, if any is required, while the difference between the refraction of the first and second meridian equals the strength of the cylinder. The axis of the cylinder always corresponds to the meridian of least refraction.

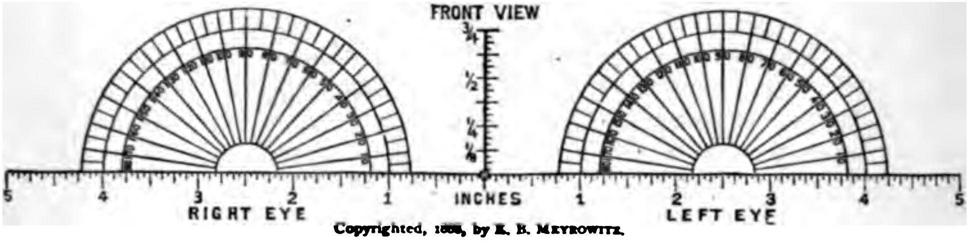

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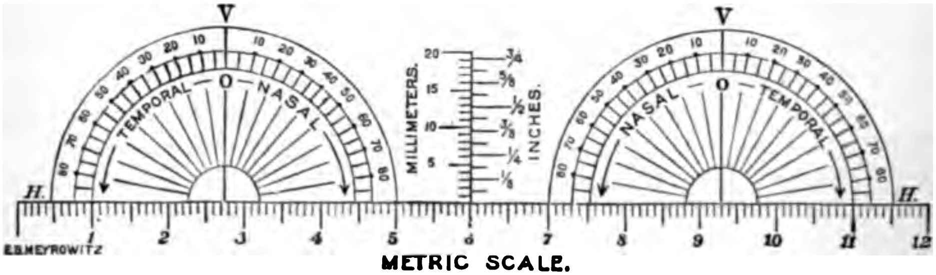
Fig. 194 A.



METRIC SCALE.

Fig. 194 B.

In each eye the position of the axis of the cylinder is denoted by the angular deviation of its upper end from the vertical meridian (V or 0°) either on the nasal or on the temporal side, and is written 5*n* = 5° nasal, 5*t* = 5° temporal, etc., down to *h* = 90° (horizontal).

Test-cards with *confusion letters* printed upon them are also frequently employed. The letters used are those that resemble each other closely, and the patient is asked to select a cylinder that removes the confusion.

Other tests, such as the corneal reflex, Placido's disk, chromo-aberration test, and Thomson's ametrometer, are sometimes used, but possess no advantage over some form of the astigmatic dial and are less accurate.

The use of the ophthalmoscope, retinoscope, and ophthalmometer in connection with astigmatism will be discussed under separate headings.

The treatment of astigmatism is always satisfactory, and consists in wearing a cylindrical lens which prevents confusion of letters or lines. The axis should be determined with certainty by repeated examinations, and any change in the general health indicates further examination to determine whether the axis has remained stationary. The glasses should be worn constantly.

Anisometropia is the term applied to marked inequality in the refraction of the two eyes. Slight differences exist in most eyes and may be disregarded. Various combinations of myopia, hyperopia, and astigmatism may be present and binocular vision may be good. Usually the vision of the worst eye is suppressed or the eyes are used alternately. This is the condition which exists in most cases of internal squint in growing children. When binocular vision is present in differences of low degree full correction of the refraction error should be prescribed. In higher grades partial correction is sufficient. If binocular vision is absent, the correcting glass should be applied to the best eye, but if vision is present in the other eye it may be increased by the wearing of a correcting lens, and by exercising it while the better eye is closed by a blinder. Careful examination into the refraction in all cases of squint will show more or less anisometropia, but the rules just given are subject to considerable variation in its correction.

Asthenopia is the technical name for the group of symptoms resulting from eye-strain due to errors of refraction or fatigue of the ocular muscles. It usually arises from excessive use of the eyes in individuals, the subject of errors of refraction or some disturbance of the extra-ocular muscle-balance. For convenience of description it may be divided into accommodative, muscular, and retinal asthenopia. *Accommodative asthenopia* is due to excessive functional activity of the ciliary muscle in attempts to correct hyperopic defects of the dioptric system. *Muscular asthenopia* results from insufficiency, inco-ordination, weakness, and strain of the external muscles of the eye. It is a common symptom of myopia. *Retinal asthenopia* is manifested by haziness and dimness of vision, photophobia, and pain, and is caused by fatigue and exhaustion of the nerve-elements concerned in vision. As in other nerve-structures, it may manifest itself as hyperæsthesia, anæsthesia, or paræsthesia of the retina. The "gold-blindness" which occurs in dentists may be mentioned as an example. Overworked school children and clerks may also be affected, and an exaggerated form is sometimes present in hysterical individuals.

The symptoms may be visual, congestive, or reflex. The *visual symptoms* consist largely in an inability to read for any length of time, particularly at night, without blurring of letters and drowsiness. Photophobia, flashes of light, and floating specks before the sight, double-vision, etc., also belong in this class. The *congestive manifestations* include congestion of the lids, conjunctiva, iris, and other parts of the eye predisposing to inflammation, and aggravating any such condition present. The formation of styes, chalazions, and crusts upon the lids is usually due to ametropia. The *reflex symptoms* include headache, neuralgia, anorexia, dyspepsia, nausea, vomiting, choreiform attacks, insomnia, nightmare, etc. The severity of the symptoms bears a direct relation to the general and neurotic temperament of the patient. Small errors of refraction in nervous women frequently produce very alarming symptoms.

The treatment consists in rest with the proper correction of the ametropia supplemented by measures which will tend to improve the general health.

ANOMALIES OF ACCOMMODATION

The function of accommodation is subject to two variations: it may be diminished or increased. Diminution of accommodation may be brought about by advancing age, drugs, infectious fevers, injuries, and constitutional disorders. An increase is caused by uncorrected errors of refraction and drugs.

Presbyopia.—The lessening of the power of accommodation that occurs as age advances is physiological and is known as *presbyopia*. It begins after forty years of age and steadily progresses, being most marked in hyperopic persons. The most prominent symptom is the recession of the near point beyond the customary reading distance.

The cause of presbyopia lies in the progressive loss in the elasticity of the crystalline lens which begins at this time of life. This loss may be hastened by the excessive functional activity of the ciliary muscle, as in hyperopia. Myopia tends to retard failure of accommodation.

The condition usually takes place to the same degree in both eyes except in high grades of anisometropia. Under ordinary circumstances both eyes may be tested at the same time, but if one eye is myopic and the other hyperopic each eye should be tested separately. In addition to recession of the near point there is always blurring of print, and considerable fatigue follows the use of the eyes even if moderate. Asthenopic symptoms are present in all degrees of uncorrected presbyopia.

The correction of presbyopia consists in wearing convex glasses that give good vision for ordinary working distance. To determine the strength of such correcting lenses the eyes are examined without the aid of a mydriatic. The distance vision is taken, and any hyperopia or other refractive error is ascertained and corrected. It is important to do this at all times, as certain forms of ametropia become manifest as accommodation fails which were previously disguised. Convex glasses are then added that bring the near point to about 13 inches for ordinary reading. The exact location of the near point depends upon the patient's occupation: the variation is obvious in musicians, machinists, typewriters, engravers, etc.

The exact strength of the lens necessary to correct presbyopia may be ascertained by subtracting the strength in diopters of the lens, the focal distance of which is equal to the patient's near point, from the strength of the lens whose focal distance corresponds to the distance at which the patient may perform near work with comfort. The remainder equals the strength of the lens to be added to the distance correction. For example, if the near point is at 50 centimetres the corresponding lens is 2 diopters; the point at which the patient wishes to perform close work is 33 centimetres, which is the focal distance of a lens 3 diopters. Subtracting 2 diopters from 3 diopters equals 1 diopter, the strength of the lens necessary.

The progression of presbyopia requires repeated examinations of the eyes about once every two years, as the rate of the failure of accommodation is about 1 diopter for every five years after forty years of age.

Age.	Failure of Accommodation.
45	1 D.
50	1.75 to 2.00 D.
55	2.50 to 3.00 D.
60	3.00 to 4.00 D.
65	3.50 to 4.50 D.

The diminution of accommodation induced by the action of drugs is nearly always complete, and is spoken of as *paralysis of accommodation*, being due to palsy of the ciliary muscle. Drugs having such action are called *cycloplegics*. They also cause dilatation of the pupil or *mydriasis*. The principal drugs of this class are atropine, bromide of methyl atropine, euphthalmin, homatropine, scopolamine, hyoscyamine, and daturine. They are employed in solution. Their effect is produced usually by instillation into the conjunctival *cul-de-sac*, but may be caused by the administration of toxic doses internally.

Paralysis of accommodation by drugs is indicated for the determination of ametropia, in persons under forty years of age, that may be masked by the action of the ciliary muscle, and also in inflammatory diseases of the eye where absolute rest is required. The use of a cycloplegic is dangerous after the age of forty years on account of the tendency towards glaucoma at this period.

For practical purposes the most important cycloplegics are atropine, homatropine, and scopolamine, on account of the certainty of their action. *Atropine sulphate* is usually employed in the strength of 4 grains to the ounce, and should be instilled by means of a medicine dropper. The upper eyelid should be held up while the patient looks down, the drop being placed in the sclera at the corneal margin. Absorption takes place through the cornea and blood-vessels at the sclero-corneal junction. One drop of the atropine solution should be instilled 3 times daily for at least twenty-four hours before the examination. The pupil is dilated at the end of twenty-two minutes after the first drop, and the drug induces paralysis of accommodation in about forty-six minutes. The maximum effect lasts about four days, after which it gradually diminishes and is absent in about ten days after the last instillation. In susceptible individuals the paralysis lasts a longer period, and sometimes flushing, rapid pulse, dizziness, dryness of throat, and slight delirium are present. The administration of some preparation of opium has an antidotal effect, but is seldom necessary, as the symptoms soon subside with the withdrawal of the drug.

Homatropine is more rapid in its action and less lasting in its effect, and on this account is preferred for ordinary examination. It is used in the strength of 10 to 15 grains to the ounce, alone or combined with cocaine. Dilatation of the pupil occurs in thirty minutes and cycloplegia is complete in one hour. The effect of the drug lasts but a few hours, and is entirely absent at the end of twenty-four hours. It may be instilled every fifteen minutes for two hours, or at longer intervals covering twenty-four hours. Dryness of the throat and flushing of the face occasionally occur, but a more frequent symptom is intense congestion of the conjunctiva. This congestion is relieved by the instillation of a drop of a 4-per-cent cocaine solution. Adrenalin is also employed for the purpose.

Scopolamine is usually employed in the strength of ½ grain to the ounce. Its action begins in from seven to ten minutes, and is complete in about half an hour. The effect lasts about twelve hours and gradually diminishes, being lost at the end of five days. It has the great disadvantage of producing alarming symptoms in susceptible individuals.

All persons under the influence of a mydriatic should wear *plane dark glasses* and abstain from attempting any close work until the accommodation is restored. As all cycloplegics are powerful poisons great care should be exercised in using them to prevent accidents. Their internal administration in toxic doses also induces cycloplegia.

Drugs such as gelsemium and conium when administered internally in toxic doses also have the power of arresting accommodation by their action on the oculomotor nerve.

Pathological cycloplegia may be applied to the paralysis of accommodation which follows local or general diseases. The third nerve is usually involved in its distribution to the ciliary muscle, and the paralysis may follow diphtheria, influenza, injuries to the head or eyeball, diabetes, syphilis, tumour of the central nervous system, or extreme general debility. The symptoms are the same as in other forms of paralysis of accommodation, and the treatment should always be directed towards the original cause, tonics and stimulants being necessary in all cases. The outlook is favourable in most cases, but in those due to traumatism the prognosis should always be guarded. Myotics may be employed, but are seldom necessary.

Increase in the function of accommodation is due to spasm of the ciliary muscle, and may be brought about by excessive eyestrain and certain drugs. Children and young adults often overcome light degrees of ametropia in this manner. Constant application to close work and poor light are also factors of importance in its production. Both eyes are affected and convergence is intensified, often causing diplopia. Asthenopia and blurring of vision promptly follow. Atropine should be instilled in all cases, and the proper correction should be prescribed.

The drugs which increase accommodation also contract the pupil and are called *myotics*, the principal of which are eserine and pilocarpine (½ to 1 per cent). Eserine salicylate or nitrate is employed in strength of from ⅛ to ½ per cent, and pilocarpine nitrate is used in a ½ to 1-per-cent solution. They find their greatest field of usefulness in glaucoma.

The internal administration of strychnine in ordinary doses increases the power of accommodation and renders vision more acute. Nicotine, the alkaloid of tobacco, also has the same effect on accommodation when given internally, but on account of its toxic properties is never employed for that purpose.

METHODS FOR THE DETERMINATION OF THE REFRACTION OF THE EYE

Before any examination is made of the refraction of the eye a history should be taken, which should include the name, age, address, occupation, duration and nature of the symptoms, and any other data that may possibly influence the ocular condition. As the ultimate aim of ophthalmology is to increase and maintain vision, the visual acuity for distance and near should be taken at all times and recorded on the history chart. A mydriatic should then be prescribed, if the patient is not over forty-five years of age, to place the eye at rest in order that latent errors may be more easily detected. This procedure necessitates a total suspension of near work for a period varying from twenty-four hours to two weeks, depending upon the drug employed. The patient should be instructed concerning this effect of the drug in order to avoid undue anxiety and alarm.

After mydriasis is complete the vision should be taken again; usually it will decrease for distance in hyperopia and increase in myopia, while in simple astigmatism and emmetropia it remains unchanged. The placing of a pinhole disk before the eye will increase the visual acuity if the eye-ground is normal.

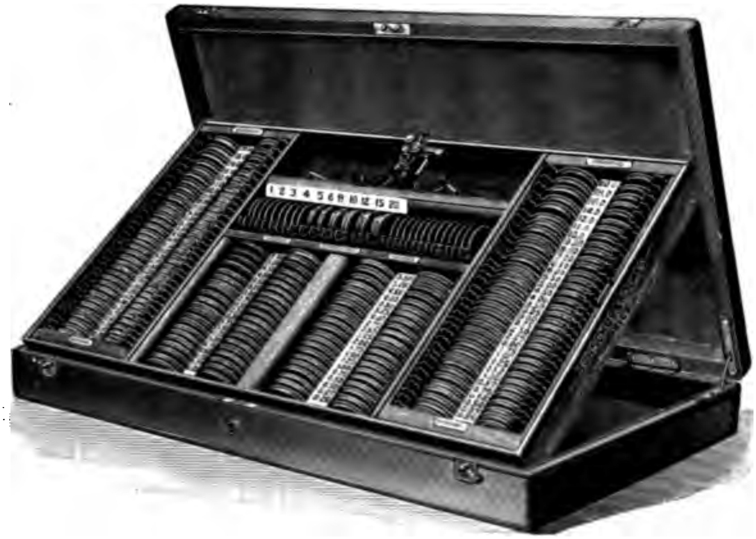


FIG. 195.—TRIAL LENSES.

The examination of the refraction may be subjective or objective. The subjective examination includes the use of the test letters and trial lenses, while the objective examination is made by the aid of the ophthalmoscope, retinoscope, and the ophthalmometer.

Trial Lenses.—A case of trial lenses should consist of a number of pairs of plus and minus spherical lenses ranging from 0.12 D. to 20.0 D., a smaller number of plus and minus cylindrical lenses, also in pairs, ranging from 0.12 D. to 6.0 D., a row of prisms varying from 0.5 to 20.0, various opaque and coloured glasses, perforated disk, stenopæic slit, blinders, and a trial frame.

The mechanism of the trial frame should be as simple as is compatible with accurate work, as the presence of a number of screws, etc., hamper the examination by their continually getting out of order. The frame should be so arranged that the cells holding the lenses may be raised or lowered or may be brought together or separated when centring the lenses before the eyes. Two cells should be provided in the frame for holding the lenses, and hooks should be placed on the front of the frame to receive any additional lens necessary. The scale markings on the front are used to denote the axis of astigmatism, and those before the left eye should begin at zero on the nasal side and run to 180 on the temporal side, while those before the right eye begin at zero on the temporal side. A failure to remember this will cause confusion in ordering cylindrical lenses, particularly in the United States, where this system of marking is employed almost exclusively.

The trial frame should be adjusted accurately when placed before the eyes, so that the pupillary centres will correspond to the centres of the lenses employed in testing, and the distance from the anterior surface of the cornea to the cells of the trial frame should approach as near as possible to the distance between the cornea and the glasses which will afterward be worn. The importance of this is shown by the fact that the effect of a convex glass is increased if carried away from the eye, and that of a concave lens is lessened by moving it away from the eye.

In proceeding with the examination of the refraction each eye should be tested separately, and after the vision has been taken efforts should be made to improve it by alternately placing before the eye plus and minus spherical and cylindrical lenses. For this purpose lenses of the strength of 0.25 D. should be employed, and whichever is selected by the patient should be further increased until the vision is no longer improved. Occasionally lenses of 0.12 D. strength are used, but the difference caused by them is often imperceptible, and the constant changing of the lenses serves to worry the patient.

If spherical lenses are selected and increased until there is no further improvement, and the vision is not yet normal, compound astigmatism should be suspected. Cylinders beginning with + 0.25 D. and — 0.25 D. should be placed alternately before the eyes at the normal axes—that is, 90 for the plus cylinder and 180 for the minus, and increased in the same manner as spherical lenses. If no improvement follows, the cylinders should be rotated until a point is reached at which it is produced. This axis will be indicated by the linear scratch at the rim of the cylindrical lens employed.

A better method for the determination of astigmatism is by the use of the stenopæic slit, as described under *astigmatism* (*q. v.*), but usually a combination of these methods is employed. Scars on the cornea, conical cornea, synechiæ, etc., interfere greatly with subjective testing of the eye. In the absence of such conditions, a failure to increase the vision by means of lenses indicates some disorder of the eye-ground and necessitates ophthalmoscopic examination.

In examination by means of the trial lenses and test type the general condition of the patient, the presence of noise in the examining or adjacent room, etc., exert considerable influence upon the result, so that more than one examination is necessary for accuracy. The use of the trial lenses should precede any prolonged examination by means of the ophthalmoscope or retinoscope when mydriasis is present, as the continued flashing of bright light into the eye tires the patient, and his answers to the subjective tests are likely to be incoherent and misleading.

An examination should also be made after the effect of the mydriatic has worn off to determine the axis of astigmatism in doubtful cases. Binocular vision with the correcting lenses should be taken for distance and near for comparison with the results obtained under mydriasis in ordering glasses.

The Ophthalmoscope.—The ophthalmoscope was designed by Helmholtz in 1851 for examination of the interior of the eyeball. Although it has undergone many modifications since that time the principle is the same in all. It consists essentially of a mirror with a central perforation mounted in a suitable handle.

Ordinarily, when looking into the pupil of an eye it appears black, because there is no light reflected from the eye-ground. The ophthalmoscope is designed to overcome this difficulty by causing the fundus of the observed eye to be a source of light. The light is thrown into the eye by the mirror of the instrument and is returned by the fundus, entering the eye of the observer through the central perforation. No rays will enter an observing eye unless it is situated exactly at the source of light, hence the necessity of looking through the central perforation of the mirror. A reciprocal relation exists between the object and the image—rays from the image are focused at the object in the same manner as rays from the object meet on the retina and form the image. From this fact it may be easily seen why it is necessary that the eye of the observer must be in the path of the returning rays to obtain a view of the fundus.

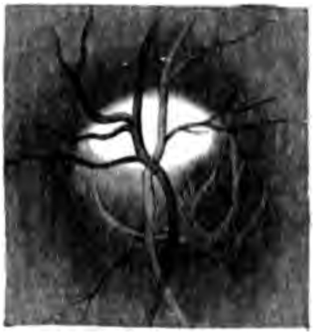


FIG. 196.—FUNDUS IN AMETROPIA

The instrument most commonly employed at the present time is probably the Loring ophthalmoscope. It consists of a concave mirror with a radius of curvatures of 40 centimetres, giving a principal focus at 20 centimetres. The sight-hole is about 3½ millimetres in diameter and is cut through the glass. The mirror is so arranged that it can be tilted from side to side to an angle of 25 degrees. Back of the mirror are two disks containing a variety of plus and minus lenses which can be rotated to the sight-hole and form a number of combinations. These lenses are used for neutralizing refraction errors in the eye of the observer and that of the patient. The mirror of the ophthalmoscope may be plane or concave, but the concave surface is usually preferred on account of the concentration of light it produces. Refraction ophthalmoscopes do not differ essentially from those usually employed for examining the fundus. The Morton and similar instruments used for estimating the refraction are equipped with a greater number of lenses, which can be conveniently and rapidly brought to the sight-hole.

In order that the ophthalmoscopic examination be satisfactory it is necessary that the accommodation in the patient's as well as in the observer's eye should be relaxed, and the refraction of both should be emmetropic. Frequently it is necessary to instill a mydriatic to enlarge the pupil. The refraction errors may be corrected by the lenses in the instrument. Cycloplegics may be used in persons under forty-five years of age, but are seldom necessary. One drop of a 5-per-cent solution of cocaine may be used in any case without producing any bad effects. The student should examine the eye-grounds in patients under atropine, so that he may familiarize himself with the appearance of the normal fundus, as no great difficulties are encountered in such cases.

The patient should be seated in a dark room, with a light (preferably an Argand burner) placed behind and to one side of the head on a level with the eyes. In examining the right eye the light should be on the right side of the patient, who should be directed to look straight ahead in the distance. The examiner should place the ophthalmoscope close to his own right eye, tilting the mirror towards the light. At a distance of about 15 inches the light should be reflected into the pupil, the red reflex of which should then be sought. The colour is usually red, but may vary in shade considerably, according to the complexion of the

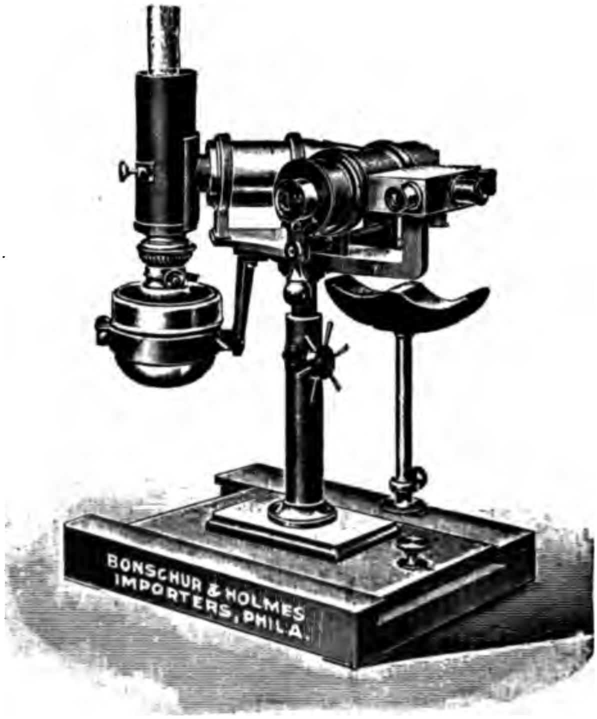


FIG. 197.—THORNER'S OPHTHALMOSCOPE FOR DEMONSTRATION PURPOSES.

patient and the amount of light entering the eye. It depends upon the abundance of chorioidal and retinal pigment. The various portions of the eye-ground may be examined by directing the patient to move the eye in various directions.

If the eye-ground presents, at a distance, a homogeneous orange-red colour, the eye is normal as regards its refraction, but if any details of the vessels of the fundus are visible, ametropia in some form is present. The patient should be asked to move the head from side to side; any movement of these vessels in the same direction indicates hyperopia, while movement in a direction opposite to that of the head is due to myopia. If the movement is confined to one meridian or is unequal in the principal meridians, astigmatism is present.

Examination by means of the ophthalmoscope at a distance serves also to detect opacities on the cornea or in the media which will appear as dark or black spots in the pupil, well defined by the contrast with the high colour of the fundus reflex. These opacities may be fixed or movable, and their location may be determined by the ophthalmoscope as well as by oblique illumination.

The displacement of the spot in its relation to the pupil as the head is moved from side to side is of great aid in locating any opacity. An absence of movement indicates that it is the plane of the iris. If it moves in a direction opposite to that of the head, it is in front of the iris, but if it moves in the same direction as the head, it is posterior to the plane of the iris.

The relation of the opacity to the eyeball, as it is moved from side to side, also serves to locate the opacity. If the eyeball is moved and the dark spot moves in the same direction, it must be situated in front of the centre of rotation, which is a point in the vitreous 10 millimetres in front of the retina; if the spot remains stationary, it is situated at the centre of rotation; and if its movement is opposite to that of the eyeball it is posterior to the centre of rotation.

Examination of the Fundus.—Two methods are employed in the ophthalmoscopic examination of the fundus, the direct and indirect. The examination may be rendered very easy in all cases by the instillation of a drop or two of a 5-per-cent cocaine solution.

The *direct method* gives rise to an erect image that is magnified from 7 to 14 diameters by the cornea and lens. The com-

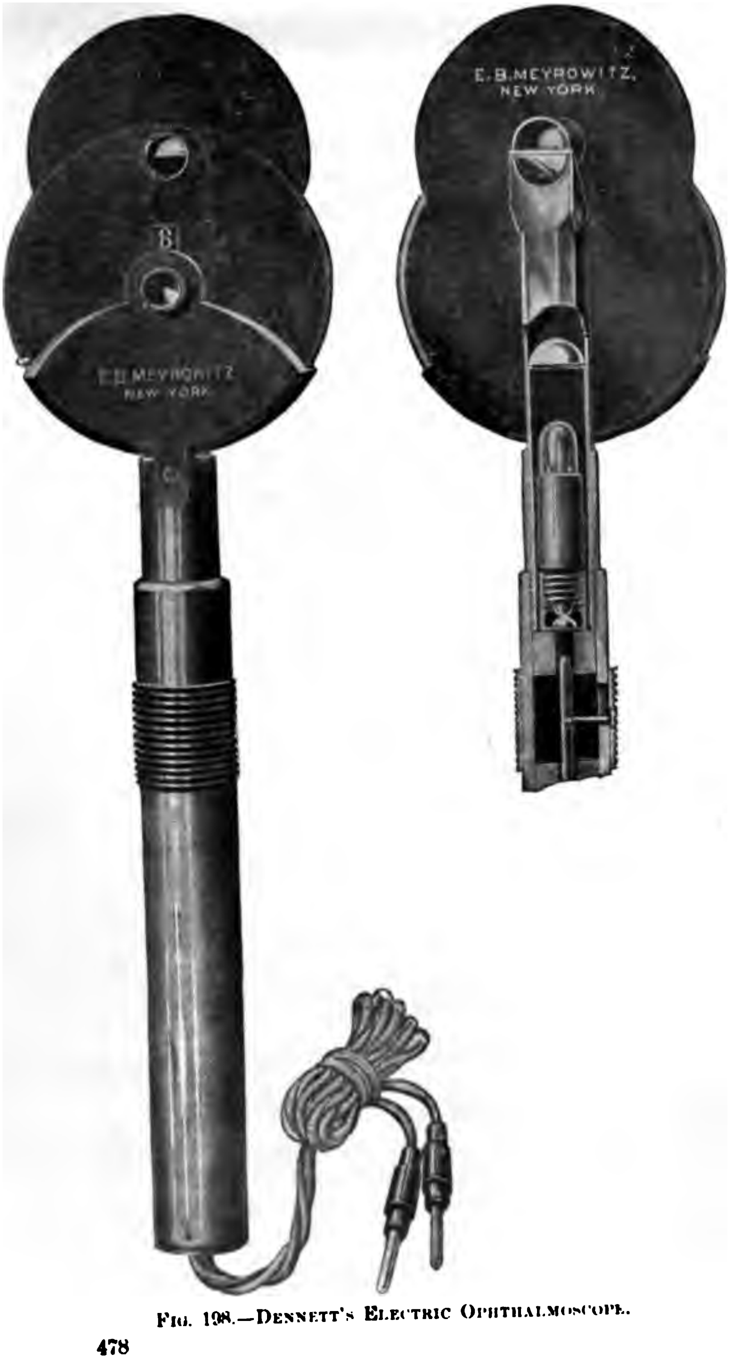


Fig. 198.—Dennett's Electric Ophthalmoscope.

bined strength of the dioptric system of the eye being equal to that of a convex lens having a focal distance of about 20 millimetres. The light used in the examination should be placed behind and to one side of the patient's head on a level with the eye. The patient is then directed to look straight ahead and the observer seeks the red reflex of the pupil by means of the ophthalmoscope held before his own eye at a short distance from the patient. The examiner approaches the patient until the distance between the instrument and the observed eye is not more than an inch. If any error of refraction is present in either eye, plus or minus lenses should be brought before the sight-hole until a clear view of the fundus is obtained. The head of the optic nerve or optic disk should spring immediately into view if the media are clear. The retinal vessels are perhaps seen first and can be traced to the optic disk, which stands out as a circular or oval reddish spot about the size of a 10-cent piece (sixpence). The real size of the optic nerve-head is 1.5 millimetres.

The central artery and vein of the retina emerge from centre of the disk and divide into superior and inferior branches that further subdivide into temporal and nasal branches a short distance from the nerve-head. The veins are about one-fourth larger than the arteries and darker in colour. They may pulsate under normal conditions, but pulsation of the arteries is a symptom of some very serious condition. Bright lines are seen over the middle of the vessels, and this light reflex is of importance, as it may be obscured by some forms of retinal inflammation.

Frequently the head of the optic nerve presents a funnel-shaped depression of varying depth due to the separation of the nerve-fibres at different levels. This depression is known as the physiological cup, and is whiter in colour than the rest of the disk and never involves the whole nerve-head, as does the pathological cup of glaucoma and optic atrophy. Grayish spots are sometimes seen at the bottom of the cup, and represent the openings of the lamina cribrosa. The optic disk is separated from the rest of the eye-ground by a narrow margin made up of two rings. The white circular ring that surrounds the nerve-head is the scleral ring, and outside of this is a pigment ring, due to the heaping up of the chorioid, known as the chorioidal ring. The borders of the disk may be obscured above and below normally, but are particularly so in ametropic individuals.

The retina is transparent except in certain inflammatory conditions, and the colour of the fundus is due to the pigment of the chorioid, pigment layer of the retina, and the chorioidal vessels. It varies with the complexion of the patient, being brighter in persons of fair complexion. The chorioidal vessels and pigment are often well marked, particularly at the periphery.

The *macula lutea* is situated about 2 disk-diameters to the temporal side of the optic disk, and may be seen by having the patient look at the top of the ophthalmoscopic mirror. It is darker than the rest of the fundus, and no blood-vessels are visible in this region. The position of the *fovea centralis* is frequently marked by one or more bright spots in the centre of the macula. By the indirect method the macula may be occasionally seen as a bright spot surrounded by a deeply pigmented area about the size of the optic disk, encircling which is a bright halo.

The *indirect method* produces an image that is inverted, and the fundus is magnified about four diameters. It has the advantage of bringing into view a greater area of the fundus than the other method. The light is placed in the same relation to the patient as in the first method. The observer is seated about one foot from the patient, and throws the light into the eye of the ophthalmoscope until the fundus reflex is obtained. A strong convex lens is placed between the eye of the patient and the instrument, intercepting the rays emerging from the observed eye and focusing them in the air between the lens and ophthalmoscope. The image formed upon the observer's retina is consequently inverted.

The results of the ophthalmoscopic examinations vary greatly according to the character of the illumination. Daylight, as pointed out years ago by Jaeger, is probably the best, as the colour details of the fundus are retained in every particular. Electric light is next in value, particularly the electric ophthalmoscope, as certain tints of the eye-ground are only partially suppressed. With the ordinary gas flame of the Argand burner the outlines of the retinal structures are well-defined but the colour reflex of the fundus is markedly impaired. This was well exemplified recently in a case of intense jaundice at the Medico-Chirurgical Hospital. The skin and mucous membranes were deeply stained yellow. The pupils were dilated with a mydriatic in order to study the eye-grounds carefully. With daylight illumination the ophthalmoscope showed the optic disk to be coloured yellow, closely approaching the tint of the conjunctiva and sclera. Below and to the outer side of the disk were ill-defined streaks of a somewhat similar colour. The rest of the eye-ground was faintly tinged with yellow. With the electric ophthalmoscope the colouration was, to a great extent, suppressed, but was by no means the colour of a normal eye-ground. The disk may be said to be of a reddish yellow. Upon movement of the instrument from side to side, flashes of white light were seen to spring from here, there, and everywhere, but particularly along the lines of the blood-vessels, constituting the so-called watered or shot-silk appearance so frequent in Indian children and those the subject of retinal anæsthesia. It was observed that this phenomenon was absent with daylight and gas illumination, and the natural conclusion to be drawn from this is that it is largely due to the character of the illumination. With the gas light, the ophthalmoscope showed no departure in the colouration of the fundus from normal. An observation of the conjunctiva and sclera through the sight-hole of the instrument showed the same deficiency in yellow in these structures.

Refraction by the Ophthalmoscope.—Although the macula is the point of most acute vision and a principal focus, it is not selected in estimating the refraction by the ophthalmoscope on account of the difficulty with which it is sometimes located. The head of the optic nerve is prominent in most eyes, and is taken for this purpose. An error, however, may arise from the optic nerve and macula being on different levels, but usually this is slight and may be disregarded.

The ordinary instrument may be used for refraction, but usually the Morton or Fox ophthalmoscope is employed on account of the greater number of lenses it contains and the ease with which they may be brought to the sight-hole.

In the *direct method* the accommodation of the patient and that of the examiner should be relaxed for accurate work. The ametropia should be corrected in the observer's eye, and the distance between the ophthalmoscope and the eye under examination should be as short as possible. After the fundus comes into view a blood-vessel at the outer margin of the nerve-head should be selected. If this appears distinct and becomes blurred by the addition of a S. 0.50 lens, emmetropia is present. If the vessel and margin of the disk are blurred at first and become distinct by the addition of plus lenses hyperopia is present, and is measured by the highest convex glass placed before the sight-hole that gives a clear image. In myopia plus lenses further blur the vessels and disk-outlines, but minus lenses render them more distinct. The weakest concave lens with which a clear image is obtained indicates the degree of myopia. If the patient or examiner exercises any accommodative effort an additional minus lens will be required to neutralize it, and for this reason the weakest lens is taken as the measurement of the myopia. In astigmatism the vertical and horizontal vessels are seen with unequal distinctness, and each should be rendered clear separately by the aid of lenses. In calculating the error of ametropia in these cases it should be remembered that the meridian of least refraction is the axis of astigmatism.

The *indirect method* is seldom employed, but the size and shape of the inverted image on approaching or withdrawing the lens from the patient's eye will indicate the form of ametropia. In emmetropia no change takes place in the shape and size of the image on withdrawing the lens. In hyperopia the shape is unchanged, but the size of the image is diminished on withdrawing the lens. In myopia the image becomes larger and the shape is unaltered under similar conditions. In astigmatism the shape of the image is particularly affected. In simple astigmatism one diameter increases or decreases and the other remains stationary. In compound astigmatism both increase or decrease to an unequal degree, while in mixed astigmatism one diameter increases and the other diminishes in size.

The Fox Refraction Ophthalmoscope.—This instrument was designed by the author while clinical assistant at Moorfields Eye Hospital, London, in 1880, and modified by him a few years afterward. The main features of this ophthalmoscope are the toothed-wheel mechanism, the short focal length of the mirror for direct examination, and a large combination of lenses. There are two mirrors with focal lengths of 8 centimetres and 20 centimetres respectively, which are set obliquely and can be rotated to any angle.

In the direct method of examination by this instrument the rays from the short focal mirror intersect each other in the crystalline lens, giving rise to an evenly diffused brilliant circle of illumination, instead of an inverted image of the lamp on the retina, so common with the ordinary ophthalmoscope.

An arrow placed upon the back of the mirror indicates the angle at which it is set. The proper position of the angle during an examination is about 25 degrees above the horizontal, with the arrowhead pointing towards the lamp. This allows the handle of the instrument to be thrown away from the patient's face and the index wheel can be easily rotated. The advantage of this is obvious.

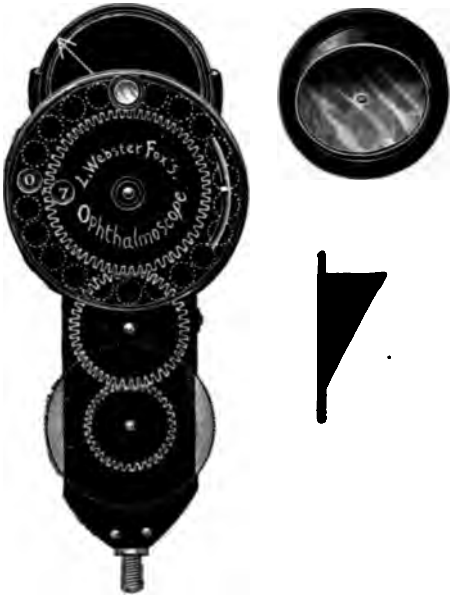


Fig. 199.—Fox Refraction Ophthalmoscope.

The short focal mirror is used in examination by the direct method to determine the refraction and pathological changes in the cornea, lens, retina, and chorioid. In very high myopia the illumination may be fainter than usual, but this may be readily overcome by lessening the distance from the lamp to the mirror. The long focal mirror is employed when the illumination by the short mirror is insufficient, as in very high myopia, in retinoscopy, and in the indirect method.

The diameter of the disk is 42 millimetres, and has 22 apertures, admitting 10 convex and 11 concave lenses. Added to this is a crescentic segment of a disk with 5 apertures containing 4 lenses. This allows, by combination, 33 convex lenses ranging from 0.5 D. to 22 D. and 42 concave lenses ranging from 0.5 D. to 35 D.

The lenses are brought to the sight-hole by an inclosed system of 3 toothed wheels; the first is set on the disk, the second is placed between the disk-wheel and the finger-wheel, and the third is the lowest, or finger-wheel, the milled edge of which projects far enough to allow the index-finger to rotate it. Each lens is accurately centred with the sight-hole on the mirror by a spring action having its point of pressure on the peripheral edge of the primary disk.

The disk and cap are held in place by screws, which can be removed, allowing the instrument to be taken apart if necessary.

Although of value in refraction, the ophthalmoscope should not replace more accurate methods, such as retinoscopy and the use of the trial lenses.

Retinoscopy.—Retinoscopy, or the shadow test, is the most accurate objective method for the determination of ametropia. The pupillary area is illuminated by light thrown into it by a plane or concave mirror, and the conduct of the light upon rotation of the mirror is then studied. The method is of decided advantage in illiterates, in children, and in high degrees of ametropia. It is easily performed and requires no aid from the patient.

The principle upon which the shadow test depends consists in finding the point of reversal or the myopic far point. The point in the air in front of the myopic eye at which an inverted image is formed is the far point or point of reversal. In emmetropia and hyperopia it is necessary to add plus lenses to give the eye an artificial far point.

For the practical application of retinoscopy, cycloplegia should be produced by suitable drugs instilled into the patient's eyes. The examination should take place in a quiet and darkened room. The light should be steady and preferably derived from an Argand gas-burner placed behind and above the patient's head. An asbestos chimney with a large circular opening in front may be placed over the lamp when the illumination is too great or uneven.

The examiner should be seated *one metre* in front of the patient, and ordinarily the plane mirror is employed. The diameter of the mirror varies with the personal likes of the examiner, but for beginners a large mirror is most serviceable, as with it there is no difficulty in detecting the retinal illumination or its movements.

Each eye should be tested separately, and it is best to cover the eye not being examined by a blinder, as the reflection from the large retinoscopic mirror may enter this eye and cause needless tiring out of the patient. In strabismus it is absolutely necessary to cover the eye that is not under examination; otherwise the patient will turn the worse eye away from the light when its pupillary area is illuminated.

The examiner should place the retinoscope close to the right eye and view the reflection caused by it through the central aperture of the mirror. The other eye should be kept open. The light is then thrown upon the face of the patient and a red reflex fills the pupillary area. The central portion of the pupillary area is brighter than the periphery, and as the mirror is moved in various directions the illumination moves also, being preceded and followed by a dark shadow. The illumination upon the patient's face always moves in the same direction as that of the mirror, but the direction of the movement of the retinal illumination depends on the presence or absence of ametropia. If the observer is ametropic, the correcting glasses may be worn without influencing the result of the examination in any manner other than to make it less difficult.

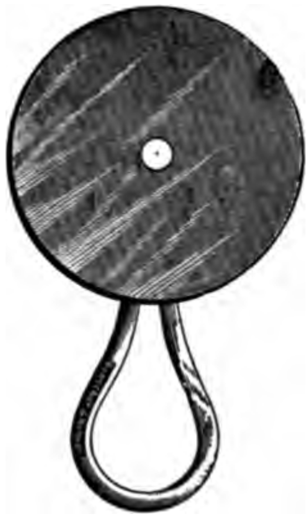


FIG. 200.—RETINOSCOPE.

The mirror should be rotated slowly from side to side on its long axis. If the plane mirror is employed and the reddish glare that fills the pupil moves in the same direction as that of the mirror, emmetropia, hyperopia, or myopia of less than 1 diopter is present, but if the movement is in the opposite direction myopia of more than 1 diopter is present. The movement of the illumination is reversed if a concave mirror is used. The movement is neutralized by concave or convex lenses placed in a trial frame before the patient's eye. The mirror is then rotated in its horizontal axis, and the movement of the illumination is noticed and neutralized by lenses. The eye may be said to be brought to a condition of emmetropia by the neutralizing lenses when the illumination disappears from all meridians at the same time. If the lenses are added until the movements are reversed the refraction error is slightly overcorrected.

The rate of movement is of importance, being slower the higher the error. The brightness of the retinal illumination also bears a definite relation to the degree of ametropia. In high degrees the illumination is dull and its edges are indistinct, becoming bright and well defined as the error is neutralized. In emmetropia, the shadow has a more or less crescentic edge, while in astigmatism a straight edge is seen.

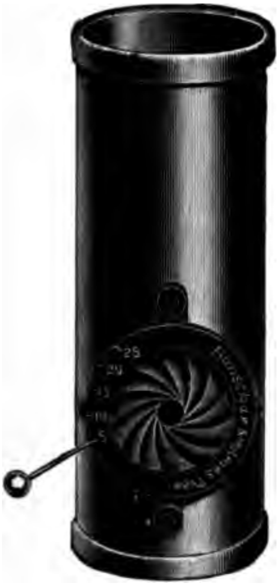


FIG. 201.—THORINGTON'S ASBESTOS CHIMNEY.

To estimate the degree of astigmatism each of the principal meridians should be neutralized separately by means of spherical lenses. The axis is indicated by the straight edge of the shadow. The degree of ametropia in the meridian of least refraction indicates the spherical lens necessary to correct the spherical defect, myopia or hyperopia. This meridian also corresponds to the axis of astigmatism. The difference between the degree of ametropia in the meridian of greater refraction and that in the meridian of least refraction equals the degree of astigmatism. In irregular astigmatism, conical cornea, etc., the central illumination alone should be studied, as it is difficult to neutralize all the movements.

To obtain the exact strength of the correcting lens it is necessary to add —1 D. to the strength of the lens required to neutralize the movement of the retinal illumination on account of the distance from the patient to the examiner being 1 metre.

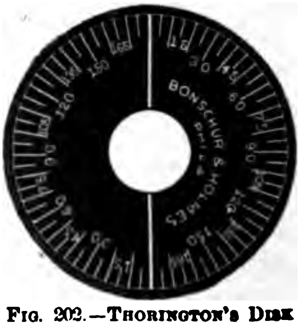


FIG. 202.—THORINGTON'S DISK FOR RETINOSCOPY.

Difficulties may arise in detecting the retinal illumination and its movements due to irregularities in the dioptric system, such as spherical aberration, conical cornea, lenticular opacities, etc. Considerable confusion is caused by the numerous peripheral shadows and their movements, but these should be ignored and the central illumination alone should be borne in mind. A metal disk with a central opening equal to the size of an average pupil if placed before the eye in a trial frame may serve to concentrate the attention on the central movement alone.

Ophthalmometer.—The ophthalmometer is an instrument used to determine astigmatism, particularly that variety due to irregularities in the curvature of the cornea. It gives the axis of astigmatism and the quantity present, but fails to indicate the character of the defect whether myopic or hyperopic. It is of value in determining the astigmatic axis in certain cases, but glasses should never be prescribed from its results alone.

The instrument consists essentially of a telescope surrounded by a graduated disk, a double-refracting prism, and an arc bearing two slides or mires. The telescope contains the double-refracting prism and is free to rotate on its own axis. An index is attached to the telescope which indicates on a scale on the graduated disk the degree of its rotation. The arc bearing the mires is firmly attached to the telescope and rotates with it. The slides or mires are of the same size, and are usually of white enamel. One is quadrilateral, while the other is cut out on one side into five steps. A horizontal black line bisects both mires. The left mire is usually fixed, while the right is movable. Artificial light is used to illuminate the mires, and is usually placed in front of the mires near the position of the patient's head, but in some models where the mires are glass the light is placed behind and allowed to shine through.

At one end of the instrument a chin-rest is provided, upon which the patient steadies the head during the examination. One eye is covered, and the other eye should look directly into the large end of the telescope. The observer views the eye through the other end of the telescope and sees the reflection of the mires upon the cornea. The double-refracting prism gives rise to two images of each mire. The peripheral images should be disregarded, and the attention should be directed towards the central figure alone. The telescope should now be turned until the horizontal line on the mires forms a continuous straight line by the touching of the edges of the mires. This position corresponds to one of the principal meridians, and its degree is indicated on the graduated disk. The arc should then be turned through 90 degrees, or at right angles to its present position. If there is no change in the relative position of the mires, as seen through the telescope, there is no irregularity of the corneal surface, but if they overlap or are separated corneal astigmatism is present. One diopter of astigmatism is present for every step on the one mire overlapped by the quadrilateral figure on the other (Javal). In some instruments the amount of the astigmatism is indicated on a scale by the distance necessary to move the mires so that their edges will just touch.

The American instruments differ in several particulars from those of foreign make and are less cumbersome and more convenient. The Chambers-Inskeep model may be taken as a type. In it the mires are of different shape and are stationary, thus maintaining the same angle of reflection from mire to cornea. The mires are made of translucent material, and are illuminated by incandescent electric lights placed behind them.

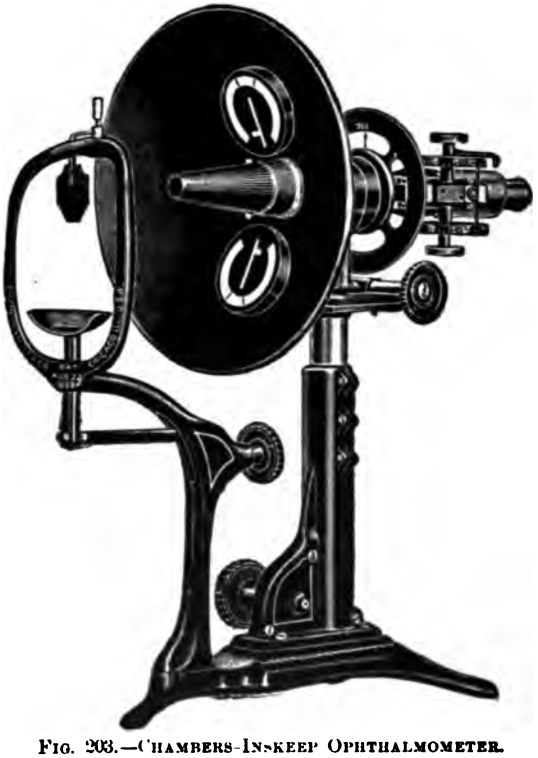


FIG. 203.—CHAMBERS-INSKEEP OPHTHALMOMETER.

This front view presents the stationary mires and head rest. The position of mires as seen on cornea is shown on page 490.

The position of the reflected mires is effected by the position of movable prisms which are fitted in an inner tube and carried back and forth as necessary by means of a finely adjusted rack and pinion. To the pinion is attached a graduated wheel or indicator, giving the radii in millimetres and the equivalent value in diopters

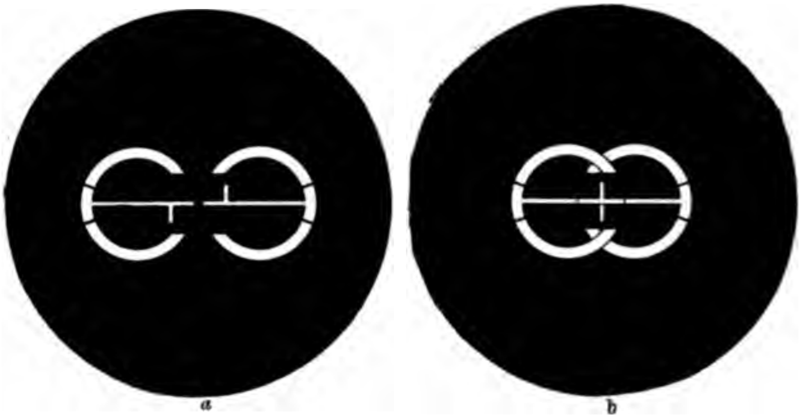


FIG. 204 *a* and *b*.—MIRES OF CHAMBERS-INSKEEP OPHTHALMOMETER.

Fig. 204 *a* represents the mires as seen on a cornea, widely separated but in perfect alignment, as on a perfect cornea, or on an astigmatic cornea at an exact axis.

Fig. 204 *b* shows images as reflected from the cornea when in primary position, and at which you take your first reading from graduated wheel.

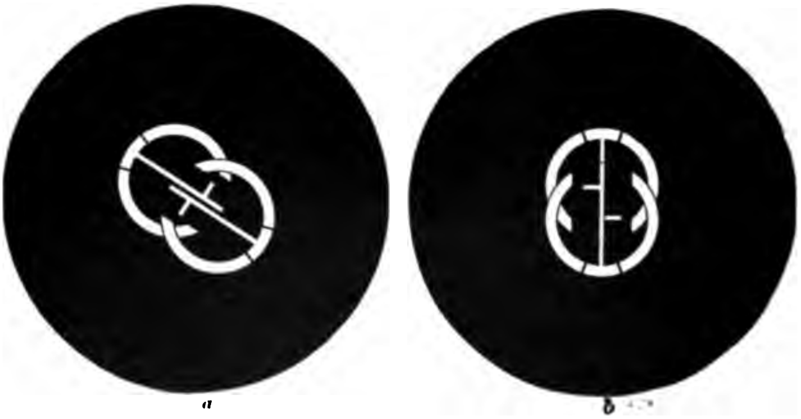


FIG. 205 *a* and *b*.—SHOWING POSITION OF MIRES.

Fig. 205 *a* represents the images as seen in a case of astigmatism midway between the two axes.

Fig. 205 *b* shows the same case of astigmatism as Fig. 205 *a* at exact axis (the secondary position) at which you again take your readings after bringing the images in position to form a perfect cross, as shown in Fig. 204 *b*.

and fractions thereof of each curvature of the cornea. In using this instrument only one eye is used at a time, as in other forms of the instrument. After proper adjustment the operator looks through the telescope and perceives the double images of the mires reflected from the cornea. These may be blurred, and in such a case the telescope is adjusted until they are brought into focus. The two innermost images are brought near the centre of the field by further adjustment, disregarding the outer images. The instrument is then revolved until the axial lines of the images form a continuous straight line. In the absence of corneal astigmatism this will be observed in all meridians. In the presence of such a condition, however, it will be seen in but two meridians, the principal meridians of the cornea. After one axis is obtained and proper adjustment of the mires is made, the refraction of the cornea is read from the scale and noted. The instrument is rotated through 90 degrees, and again adjusted and the refraction of the meridian determined. Two pointers are employed to indicate the refraction on the scale, the interval between which represents the astigmatism. Irregular astigmatism is indicated by the distortion of the circular images of the mires.

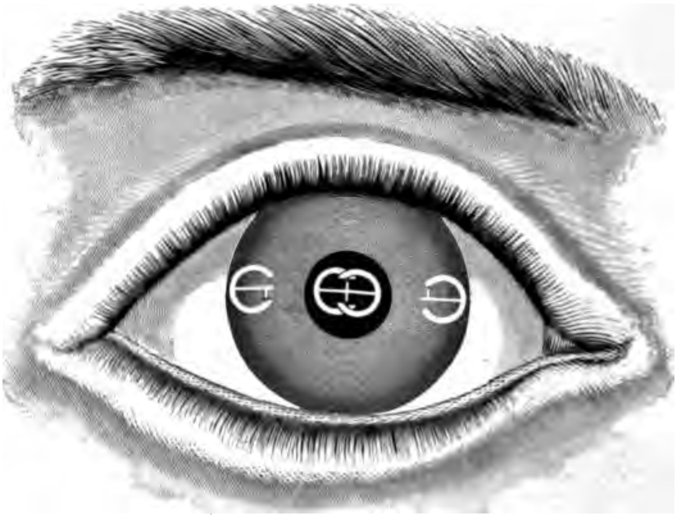


Fig. 206.—Showing Mires on the Cornea.

The usefulness of the ophthalmometer is greatly limited, and its expense is an additional disadvantage. Used in connection with the other methods for determining astigmatism it is a great aid.

ORDERING OF GLASSES

In hyperopia, as has already been shown, it is necessary to prescribe convex or plus spherical lenses to overcome the defect and to relieve the symptoms of eye-strain. The highest convex glass with which the patient can see distinctly at 6 metres distance indicates the degree of hyperopia, but this is not prescribed as a rule. If the patient is to wear glasses constantly a reduction of from 0.25 D. to 0.75 D. should be made, on account of the blurring of distant vision that occurs when full correction is worn, particularly in young adults. If the glasses are prescribed only for close work to relieve eye-strain incident to the patient's occupation, full correction should be ordered. In cases where the symptoms of eye-strain are marked it is frequently necessary to order full correction for constant use, ignoring the distance blurring for a time, and later reducing the strength of the lenses so that vision is distinct for distance as well as for near.[1] It is not an uncommon practice to order very low correction at first, gradually increasing the strength of the lens by adding 0.25 D. every month or two until full correction is won. In young children full correction is nearly always easily borne, but it must be kept in mind that the refraction error physiologically undergoes change with the growth of the child, hence examinations should be made every two years.

As presbyopia supervenes the manifest hyperopia should be ascertained, and its full correction should be ordered. In all cases the age, occupation, severity of symptoms, temperament, etc., influence the ordering of eye-glasses, but comfort is obtained always by reducing the correction about 0.50 D. in prescribing. The following formula for simple hyperopia may be taken as an example of an oculist's prescription:

For J. S. ℞

$$\left.\begin{array}{l} \text{O. D.} + \text{S. } 1.50 \\ \text{O. S.} + \text{S. } 1.50 \end{array}\right\} \text{For constant use.}$$

---

[1] The author frequently prescribes atropine sulphate, grain $\frac{1}{100}$, and aqua destil., ounce j, dropped into the eye once daily until distant vision becomes clear. This solution does not produce mydriasis, and the patient is saved much annoyance.

In myopia, the weakest concave glass accepted by the patient under the influence of a mydriatic is taken as an index of the degree of myopia. Without a mydriatic, a myopic individual will accept lenses out of proportion to the defect. Upon wearing correcting lenses after mydriasis has passed off distance vision will be distinct, but the near point will be found to have receded. By reducing the strength of the lenses a point can be selected at which near work can be performed with comfort. In low degrees of myopia a reduction, usually 0.50 D., that will place the near point at 13 inches is sufficient, and the lenses thus ordered should be worn constantly. In high degrees the reduction necessary is often so great as to require the ordering of distance and near glasses.

A formula for simple myopia:

℞

$$\left.\begin{array}{l}\text{O. S.} - \text{S. } 1.75\\ \text{O. D.} - \text{S. } 1.75\end{array}\right\}\text{ For constant use.}$$

In presbyopia the hyperopia or myopia should first be corrected to its full extent. The additional convex glasses necessary to correct the presbyopia should be such that distinct vision is obtained at a convenient working distance irrespective of the patient's age. The occupation of the patient should, however, always be taken into consideration. An attempt to follow fixed rules in presbyopia frequently causes unsatisfactory results, so that hard-and-fast rules should be replaced by judgment and the results of experience. In myopia, as has already been stated, presbyopia is retarded, while hyperopia tends to hasten its advancement. It does not take place to the same extent in all hyperopic individuals, and sometimes is unequal in two eyes of the same person. The distance vision should be corrected, and the lenses necessary for the presbyopia should be incorporated with the distance lenses to give satisfactory reading glasses. This may be accomplished by ordering two pairs of glasses, one for distance and the other for close work, in which the presbyopic correction has been added to the first. A more convenient method is to add circular or elliptical convex slips (supplemental lens), equal to presbyopic correction to the distance lenses. The slips are cemented to the distance lenses at their lower portion by Canada balsam and constitute bifocal glasses. They should be made very thin at their upper edges so that the line of junction will be hardly perceptible. Their great advantage is that only one pair of spectacles is necessary. They may also be made by inserting the bifocal slip into a ground-out portion of the distance lens (Borsch), or the distance and reading correction may be ground on the same lens. In wearing bifocals difficulty may be encountered at first, owing to the line of junction intercepting the central vision. This gives rise to diplopia, but can be readily overcome by proper adjustment of the spectacles. At best they are somewhat annoying for a period of four or five days, but patients soon become accustomed to them.

Formulas:

℞ For J. S.
O. D. + Sph. 1.25, + cyl. 0.50, ax. 90°;
O. S. + Sph. 1.50, + cyl. 0.25, ax. 90°.
For constant use—distance lenses.

℞
O. D. + Sph. 2.75, + cyl. 0.50, ax. 90°;
O. S. + Sph. 3.00, + cyl. 0.25, ax. 90°.
For close work—reading glasses.

Bifocals are prescribed when it is desirable that the patient wear both distant and reading glasses in the same frame.

Astigmatism requires the wearing of the cylinder obtained during mydriasis. The amount of astigmatism is influenced very little by mydriasis, but the axis is likely to undergo considerable variation. On this account it is common to examine for astigmatism after the effect of the mydriatic has passed off and to order the cylinder at the axis thus obtained. The real axis of astigmatism, however, is the axis demonstrated while the eye is at absolute rest, and for this reason the author prefers to order from the mydriatic examination. When the axes are asymmetrical or against the rule the patient often experiences considerable distortion of objects at close range, while distant objects retain their shape and form. This annoying symptom should occasion no alarm to the patient, as it soon disappears with the constant wearing of the lenses. It is always important to have the spectacles or eyeglasses so fitted that the axes of the lenses correspond to the axes of the lenses in the trial frame, otherwise disturbing symptoms will arise that may be attributed to inaccuracy in the examination or in the prescribing of lenses. The patient should be instructed to have the glasses adjusted and centred at frequent intervals to avoid this complication.

Formulas:

Simple Astigmatism

℞ For J. S.
O. D. + Cyl. 0.50, ax. 90°;
O. S. + Cyl. 0.75, ax. 105°.

Compound Hyperopic Astigmatism

℞ For J. S.
O. D. + Sph. 1.25, + cyl. 0.50, ax. 90° }
O. S. + Sph. 1.50, + cyl. 0.25, ax. 90° } For constant use.

Mixed Astigmatism

℞ For J. S.
O. D. — Sph. 1.00, + cyl. 3.00, ax. 90° }
O. S. — Sph. 1.50, + cyl. 3.25, ax. 90° } For constant use.

It is very important in ordering cylindrical lenses to always indicate the axis of the lens, to prevent unnecessary embarrassment.

Prisms are often ordered, and the strength necessary may be placed before only one eye or may be divided between both eyes. The degree of the prisms and the situation of the base should always be indicated. Decentring of lenses may be employed in place of prisms. The amount of decentring necessary to produce a certain prism effect may be obtained by dividing the number of centrads required by the strength of the lens in diopters; the quotient is the number of centimetres necessary. Full-strength prisms cannot be worn with comfort.

Spectacle frames should be prescribed as often as possible, and the frames should be sufficiently strong to maintain perfect adjustment. If plane spherical lenses are ordered or if the nose can be fitted to hold them straight, there is no objection to eyeglasses, but usually such is not the case, and the focus of the lenses changes every time they are placed before the eyes. The size of the lens or "eye" should be such as to afford protection to the eye and should be of the same shape. Their centres should correspond with the pupillary centres and should be perpendicular or very slightly inclined to the line of vision. For close work the inclination should be greater than this to avoid undue bowing of the head to obtain distinct vision. All these points should be carefully examined and the glasses neutralized before the patient is discharged. The methods of neutralization of lenses have already been described in a previous chapter.

Although the fitting of spectacle frames is the province of the optician, the oculist is occasionally so placed that it is necessary for him to take the measurements. The pupillary distance should first be taken by measuring the distance in millimetres from the outer edge of one pupil to the inner edge of the other pupil. This serves to indicate the positions of the centre of the lenses.

The temple or side pieces should be measured from the top of the ear to the plane of the lenses or to a horizontal line just beyond the eyelashes. The nose-piece or bridge is the most important; it may be measured by selecting from a number of frames one which may be moulded to fit the nose and measuring the bridge of this frame, or a piece of lead wire may be moulded to the nose at the position the bridge will occupy. The height of the bridge is the distance from its top to a horizontal line passing through the pupillary centres or centres of the lenses. The distance between the lower arms equals the width of the nose and also the bridge. The relation of the bridge to the plane of the lenses, whether inside or outside, and the distance, should also be taken. The shape of the bridge is indicated by the shape of the lead wire. The size of the lens, when not otherwise indicated, is taken as " 0," the size of the average eye. A prescription giving the dimensions just stated can be filled by any optician, but some skill and ingenuity is yet required to fit the glasses before the eyes satisfactorily.

The care of spectacles requires a few words, as the work of a skilled oculist may be more or less disturbed by their improper use. The hooks back of the ears should be removed first in taking off spectacles to avoid straining the delicate hinges. They should be folded up as little as possible, and not allowed to rest face down, or the polish will be destroyed in a short time. Ordinary water or ammonia water may be used to cleanse the glasses. Under no circumstances should heat or turpentine be employed in cleansing bifocal glasses, as the cemented slips will separate. The end-piece and not the bridge should be held during such procedure.

CHAPTER XXI

EXTRA-OCULAR MUSCLES

THE extra-ocular muscles may be divided into two sets, the palpebral and the orbital.

The palpebral muscles include the *orbicularis palpebrarum*, the *tendo-palpebrarum*, the *corrugator supercilii*, and the *tensor tarsi*. The orbicularis palpebrarum is a circular muscle of sphincter character, situated at the circumference of the orbit and surrounding the eyelids. The fibres are concentrically arranged and arise from the internal angular process of the frontal bone, from the nasal process of the superior maxilla in front of the lacrymal groove, and from a short tendon, the tendo-palpebrarum, at the inner angle of the orbit. The fibres then take an outward direction and expand into a broad flat layer which surrounds the eyelids and orbit, eventually blending with the facial muscles in this vicinity. The function of the orbicularis is to close the eyelids, and may be voluntary or involuntary as in blepharospasm.

The **tendo-palpebrarum** or **tendo-oculi** is an exceedingly short and narrow muscle situated at the inner angle of the orbit attached to the nasal process of the superior maxilla, anterior to the groove for the nasal duct. It crosses the lacrymal sac and divides into two slips, each of which is attached to the inner extremity of the corresponding tarsal plate. As the lacrymal sac is crossed an aponeurosis is given off from the posterior portion that expands over the sac and is attached to the ridge on the lacrymal bone. This muscle gives attachment to the orbicularis palpebrarum and the tarsal plate and serves to suck the tears into the lacrymal sac. As the eyelids are closed the tendo-oculi is rendered tense, and the wall of the lacrymal sac is drawn outward and forward. A vacuum is formed, which is readily overcome by the external pressure forcing the tears into the sac.

The **corrugator supercilii** is a small pyramidal muscle placed at the inner extremity of the eyebrow. It takes its origin from the superciliary ridge and is inserted into the under surface of the orbicularis. It serves to produce frowning by drawing the eyebrow downward and inward.

The **tensor tarsi,** or Horner's muscle, is also situated at the inner side of the orbit, but behind the tendo-oculi. At its origin it is attached to the crest of the orbital surface of the lacrymal bone, and afterward divides into two slips which cover the lacrymal canal and are inserted into the tarsal plates internal to the puncta lacrymalia. It serves to draw the eyelids and extremities of the lacrymal canals inward and to compress them against the surface of the eye, thus placing them in position to receive the tears.

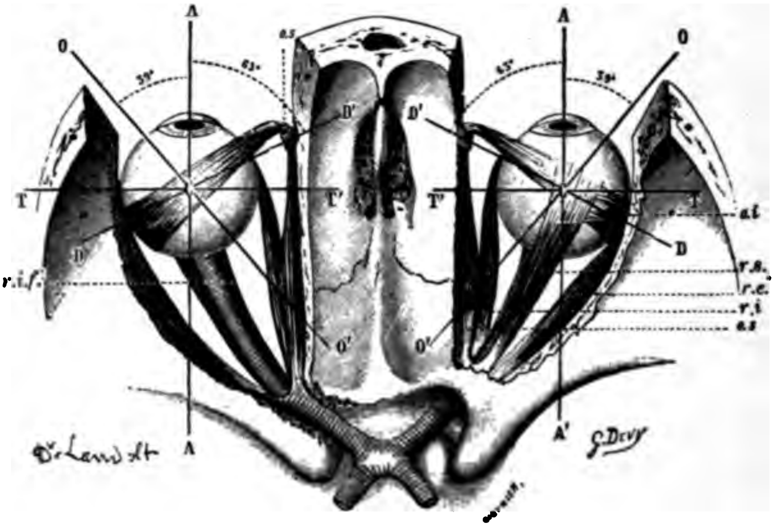


FIG. 207.—EXTRA-OCULAR MUSCLES.

This group of muscles is supplied by the facial nerve, injury or disease of which results in loss of function in the muscles thus supplied. Frequently, oculists are consulted regarding profuse and continued lacrymation which is unconnected with ocular or lacrymal disease, but has its cause in a mild attack of Bell's palsy. This set of muscles is also of importance on account of its relations to plastic operations upon the eyelids and operations upon the lacrymal apparatus.

The orbital muscles consist of the *levator palpebræ superioris*, the *superior rectus*, the *inferior rectus*, the *internal rectus*, the *external rectus*, the *superior oblique*, and the *inferior oblique*.

The **levator palpebræ superioris** arises from the under surface of the lesser wing of the sphenoid above and in front of the optic foramen, and is inserted into the anterior surface of the superior tarsal plate. A thin aponeurosis of this muscle is inserted into the skin of the eyelid. Its function is to elevate the lid, and is the direct antagonist of the orbicularis muscle. It is supplied by the third nerve, injury or disease of the filament sent to the muscle inducing loss of function or drooping of the upper lid (ptosis).

The **superior rectus** is the thinnest and narrowest of the straight muscles. It takes its origin from the upper margin of the optic foramen and fibrous sheath of the optic nerve, and is inserted into the sclera by a tendinous expansion about 7.54 millimetres from the corneal limbus.

The **inferior rectus** arises from a tendon common to it and the internal rectus, which is attached to the lower and inner part of the optic foramen, and from the fibrous sheath of the optic foramen. It passes along the floor of the orbit and is inserted into the sclera about 7.0 millimetres from the corneal margin.

The **internal rectus** arises from a common tendon at the posterior portion of the orbit. It passes along the inner wall of the orbit and is inserted into the sclera by a tendinous expansion about 6.91 millimetres from the corneo-scleral junction.

The **external rectus** arises from two heads, one from the common tendon of the internal and inferior rectus, the other from the upper margin of the optic foramen. These unite to form the body of the muscle, which follows the external wall of the orbit and is inserted into the sclera about 7.85 millimetres from the corneal limbus.

The **superior oblique** takes its origin from the lesser wing of the sphenoid at the upper margin of the optic foramen. It passes forward along the inner wall of the orbit to the inner angle, where it terminates in a rounded tendon. This tendon passes to a pulley-like process beneath the internal angular process of the frontal bone. The tendon is now reflected backward and inserted into the outer and posterior surface of the sclera midway between the cornea and entrance of the optic nerve, about 17.9 millimetres distance from the corneal limbus.

The **inferior oblique** arises from a depression in the superior maxillary bone in the anterior third of the orbit. Its course is outward, backward, and upward, and is inserted into the outer portion of the sclera about 17 millimetres from the corneal margin and 5.5 millimetres from the entrance of the optic nerve.

The function of the muscles which are inserted into the sclera is to rotate the eyeball in various directions. The **external rectus** and the two oblique are abductors and rotate the eye outward, while the internal, inferior, and superior recti are adductors and turn the eyeball inward. The four recti, acting singly, will turn the eye in the direction indicated by their names. Circumduction of the eyeball is produced by the alternate action of the four recti muscles. The action of two contiguous recti of one eye carries the

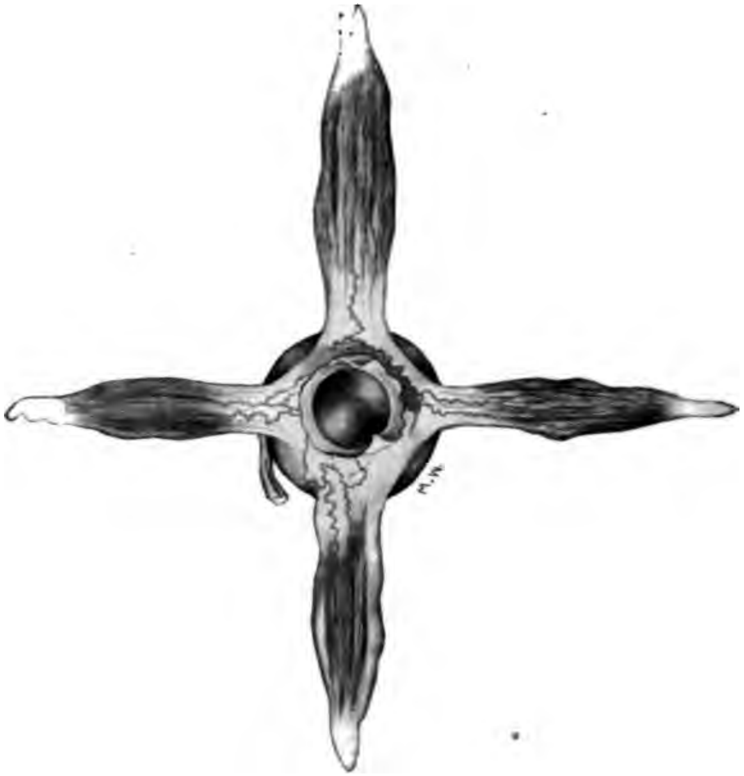


FIG. 208.—RECTI MUSCLES.

eye in the diagonal of their direction: upward and inward, upward and outward, downward and inward, or downward and outward. The superior rectus and inferior oblique are elevators of the eyeball, while the inferior rectus and superior oblique serve to turn the globe downward. The superior oblique and superior rectus also cause internal rotation of the upper part of the eye, while the lower portion is turned inward by the inferior oblique and inferior rectus. The actions of these muscles are at all times harmonious and reciprocal, and excessive functional activity on the part of the abductors or adductors is restricted by prolongations from Tenon's capsule, known as check ligaments.

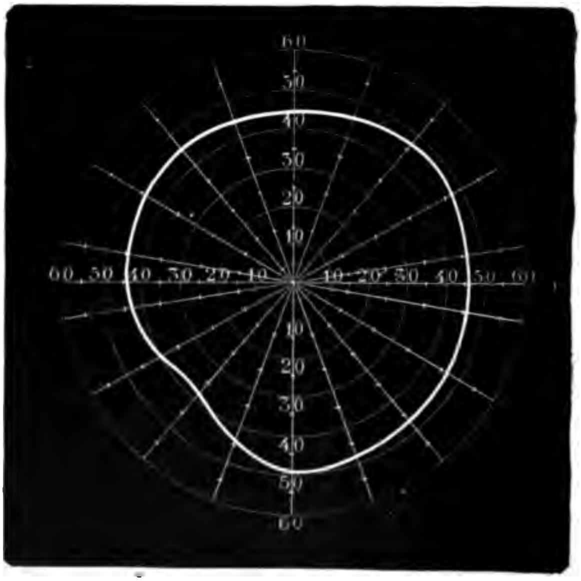


Fig. 209.—Normal Field of Fixation. (After Landolt.)

The third or oculomotor nerve supplies all these last-mentioned muscles with the exception of the superior oblique and external rectus. The superior oblique receives its innervation from the fourth cranial nerve, and the external rectus is supplied by the sixth or abducens nerves. The centres which control the movements of the individual muscles correspond to the motor area near the facial centre in the brain and to the nuclei of origin of the nerves that supply the muscles.

The Field of Fixation.—The greatest extent of movement of the eyes is downward and the least is upward. The field of fixation includes all points towards which both eyes can be directed without changing the position of the head. In the normal eye it extends about 45 degrees upward, inward, and outward, and about 55 degrees downward.

CO-ORDINATION AND INCO-ORDINATION

Every movement of one eye is accompanied by a corresponding movement in the other eye except in rare cases, where normally one eye may be moved independent of the other. These simultaneous movements may occur in the same direction, causing the visual lines to be parallel or in such direction that the visual lines converge. The object of this co-ordination of the muscles of both eyes is to direct the visual axes so that the two images of any object may fall on corresponding portions of the two retinas. This causes effacement of the normal blind spots, and the two images are readily fused into one.

A special centre in the brain governs this co-ordination of the ocular muscles. It is located in the nates of the corpora quadrigemina. Stimulation of the right side gives rise to movements of both eyes to the left, while stimulation of the left side causes movement to the right. If the stimulation is applied to the posterior portion in the median line convergence is brought about, and stimulation of the anterior portion in the middle line causes an upward movement with a return to parallelism, both movements being accompanied by the usual associated movements of the pupil.

The perfect co-ordination of the ocular muscles with binocular vision is also known as muscle equilibrium or balance. Its maintenance depends upon the condition and strength of the muscles as well as upon the nerves and nerve-centres. A departure from the normal is frequently overcome by increased innervation, so that equilibrium and binocular vision are maintained, but symptoms belonging to the group known as muscular asthenopia occur as a result.

Perfect binocular vision, or the blending of two images into one, occurs only when the two images fall on corresponding points of the two retinas. These points are as follows: The upper portion of the retina of the right eye corresponds to the upper portion of the same structure in the left eye, and the lower portion of the right retina also corresponds to that of the left, but the nasal portion of the retina of the left eye corresponds to the temporal of the right eye, and the temporal side of the left corresponds to the nasal side of the right eye. Any disturbance of the harmonious action of the ocular muscles causes the images to be formed on non-corresponding points, and binocular vision is destroyed. Diplopia does not always occur, because the image formed in the non-fixing eye is blurred by the dioptric system, and its perception is retarded by being thrown upon a portion of the retina less sensitive than the fovea centralis. Usually, however, by careful testing diplopia can be demonstrated in imperfect muscle balance.

The position of rest of the ocular muscles is probably divergence of the visual axes about 8 to 10 degrees from parallelism. The amount of convergent effort necessary to bring the visual axes parallel is called negative convergence. Positive convergence consists in bringing the visual axes from parallel to approach each other. It varies from 45 to 65 degrees, and bears a direct relation to accommodation.

The strength of the ocular muscles in regard to their power of maintaining muscle equilibrium may be determined by placing prisms before the eyes, always bearing in mind the fact that rays of light entering a prism are deflected towards its base. The inward rotation necessary to overcome the diplopia produced by prisms, bases out, is known as the power of adduction. The power of abduction is the power of rotating the eyes outward to overcome diplopia produced by prisms, bases in. The power of rotating the eyes in the horizontal meridian, so that the effect of prisms, bases up or down, is overcome, is known as sursumduction. The strength of the highest prism that can be overcome maintaining perfect binocular vision indicates the power of the muscles.

Inco-ordination of the extra-ocular muscles arises from a great variety of causes, and is known as muscle imbalance, disturbance of equilibrium, and functional anomalies of the extra-ocular muscles. The descriptive nomenclature of the various forms of inco-ordination generally accepted was suggested by Stevens, of New York.

For latent squint, or the disturbance usually of slight extent and readily overcome:

Orthophoria—perfect muscle balance or co-ordination.

Heterophoria—disturbances of muscle equilibrium or inco-ordination.

Hyperphoria—a tendency towards upward deviation of one eye.

Esophoria—a tendency toward inward deviation.

Exophoria—a tendency toward outward deviation.

Hyperesophoria—a combination of a tendency of one eye to deviate upward and inward or of its fellow to deviate downward and inward.

Hyperexophoria—a tendency towards upward and outward deviation of one eye or of downward and outward deviation of its fellow.

When the deviation of the visual axis is absolute and perfect binocular fixation cannot be effected, the following terms are employed:

Orthotropia—perfect binocular fixation.

Heterotropia—deviation from parallelism, or squint.

Esotropia—inward deviation, or convergent squint.

Exotropia—outward deviation, or divergent squint.

Hypertropia—deviation of one eye upward and of the other downward.

Combinations of these deviations may also occur.

TESTS FOR INCO-ORDINATION OF THE EXTRA-OCULAR MUSCLES

All these tests depend upon the detection of diplopia and upon the ascertaining which eye fails to " fix " when the patient looks at an object. Two images are formed, and their position indicates the character of the inco-ordination. If one eye is turned in, the false image will appear to be situated on the same side of the object as the eye. This is known as homonymous diplopia. If the eye turns outward the false image appears to be on the opposite side. This is called heteronymous or crossed diplopia. Disturbances of the vertical muscle balance are always divergent in character and crossed diplopia is the result. The eye that deviates upward is taken as the defective or hyperphoric eye, and its image is below that of the fixed eye.

In testing the muscles for functional disturbance the strength of each group should first be taken. This is known as muscle phorometry. The patient is seated at 6 metres distance from a steady point of light or suitable test-card. The abductors should be tested by placing prisms, bases in, in a trial frame before the patient's eye until fusion of the two images thus produced is no longer possible. The highest prism overcome indicates the strength of the abductor muscles, and is usually 6 to 8 degrees. To measure adduction the prisms are placed bases out. Normally, the highest prism overcome varies from 20 to 30 degrees. Supraduction and infraduction are determined by placing the bases down or up. They are usually of equal strength, and are seldom more than 2 or 3 degrees.

The excursions of the eye should always be observed by requesting the patient to fix the gaze upon a pencil or similar object held about 13 inches from the eye. The object is then moved in various directions, and the

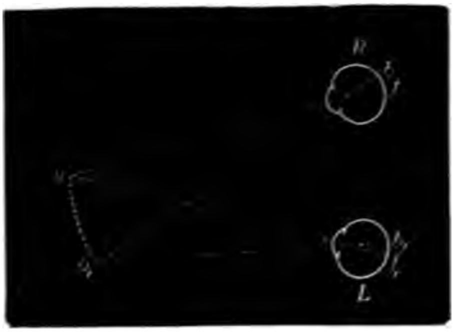


Fig. 210.—Binocular Single Vision.

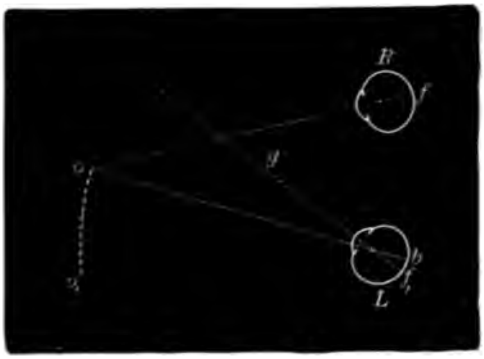


Fig. 211.—Homonymous Double Images.

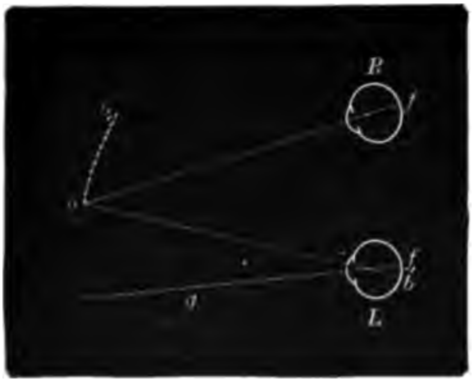


Fig. 212.—Crossed Double Images.

movements of the eye in following the object should be carefully noticed. Under ordinary conditions the inward movement is about 45 degrees, the outward movement 45 to 50 degrees, the upward movement about 40 degrees, and the downward movement about 60 degrees.

Another test easily performed is the *cover test.* One eye should be covered while the other is fixed upon some object held at about 13 inches distance. If on removal of the cover the non-fixing eye moves inward to fix upon the object, outward deviation was present while the eye was covered. If the eye just uncovered moves outward, inward deviation was present. If the released eye turns upward in fixing on the object a downward deviation was present; a reversal of the movement indicates an upward deviation. As the eye is at rest during the period in which it is covered, the deviation it then undergoes indicates the deviation towards which it tends when not excessively stimulated for binocular fixation.

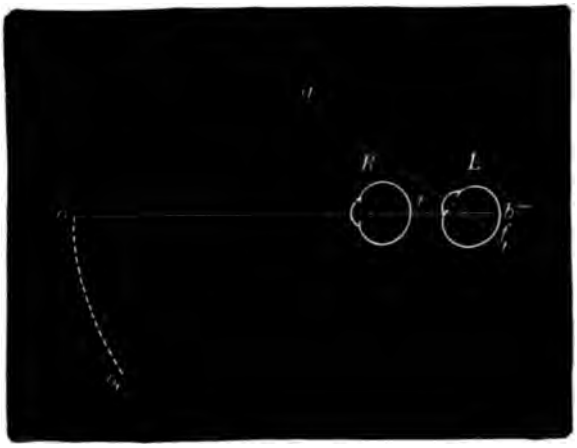


FIG. 213.—DOUBLE IMAGES, WITH DIFFERENCE IN LEVEL.

Insufficiency of the ocular muscles may also be demonstrated by bringing the object, on which the eyes are fixed, to within 4 or 5 inches of the patient. As accommodation increases convergence should increase proportionately, but if the internal muscles are too weak or the external muscles are too strong this will not occur.

Sometimes the placing of a coloured glass before the eye will bring out the diplopia present and serve to locate the position of the images. If the coloured glass is placed before the left eye and the coloured image is to the left of the true image, homonymous diplopia is present, and the condition is that of esophoria or internal deviation. If the coloured image is to the right of the true image, crossed diplopia is present, and the muscle condition is that of exophoria or outward deviation.

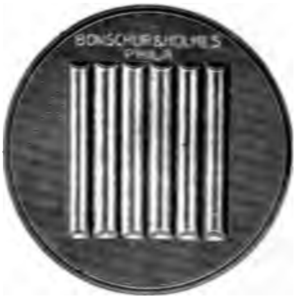


FIG. 214.—MADDOX ROD.

Maddox's Test.—Another convenient test is the Maddox rod, which consists of a glass rod or series of glass rods, which if placed in a frame before the eye will distort a point of light at 6 metres distance into a streak of light running at a right angle to its long axis. Its effect is that of a high cylinder, and may be replaced by one. The glass is sometimes tinted. For the practical application of this test the patient should be seated in a dark room about 6 metres distance from a small, steady point of light. The disk in which the rod is mounted should be placed before the left eye. A blank disk should be placed before the right eye. The rod should be placed so that it is exactly in front of the pupil, and its long axis should be horizontal at first. As the patient looks towards the light a vertical streak of light is seen. The rod is then covered and the right eye is uncovered, so that the natural point of light may be seen. The cover is removed from the rod, and if there is perfect muscle equilibrium the streak will be seen to pass directly through the light. If the streak is to the left of the light, esophoria is present; but if the streak is to the right of the light, exophoria is present. The degree of insufficiency may be measured by the strength of the prism necessary to bring the streak directly through the light. The rotary prism of Crété or Risley is best adapted for this purpose.

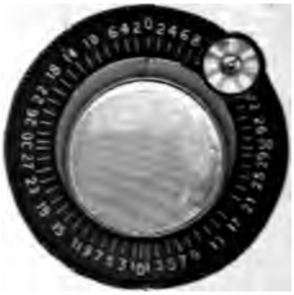
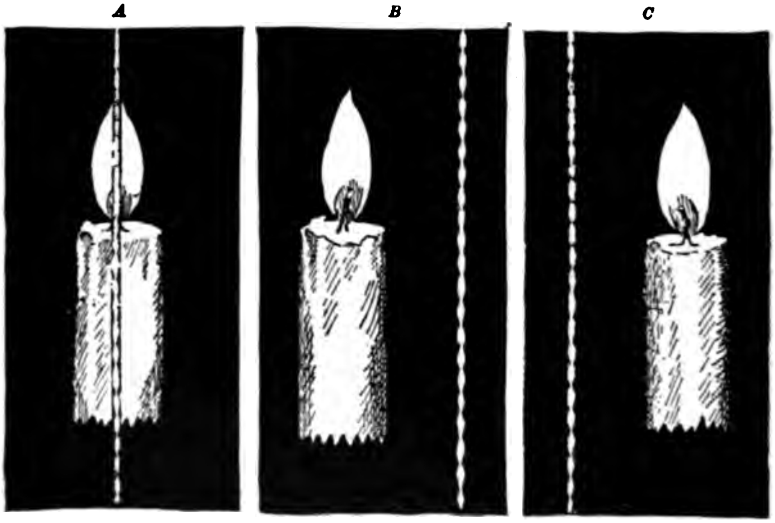


FIG. 215.—RISLEY PRISM.

To test for hyperphoria the disk containing the rod is rotated until the rod is vertical. This causes the streak to appear horizontal. If the vertical muscles are perfectly balanced the streak will pass through the centre of the light, otherwise it will pass above or below it. If the streak is above the light, the left eye turns down, but if it is below, the left eye turns upward. The prism necessary to bring the streak through the light indicates the degree of hyperphoria, but the eye tested and the position of the prism's base should always be specified in noting the result.



ORTHOPHORIA

EXOPHORIA
Prism base in to correct.
(See Fig. 218.)

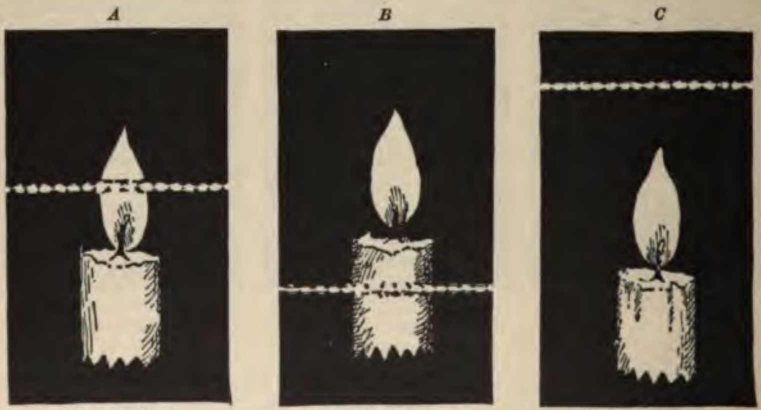
ESOPHORIA
Prism base out to correct.

FIG. 216.—MADDOX ROD TEST FOR LATERAL DEVIATION WITH ROD BEFORE THE LEFT EYE.

A, the line passes through the flame—Orthophoria; *B*, the line passes to the right of the flame latent—Exophoria; *C*, the line passes to the left of the flame latent—Esophoria.

A more satisfactory test is that in which diplopia is produced by placing prisms before the eyes. It may be performed by placing a prism of 10 degrees, base up or down, before one eye and a tinted glass before the other. Vertical diplopia is then produced. If orthophoria is present the images will be directly above each other, so that a vertical line drawn from one will pass directly through the other. If the prism is placed, base down, before the right eye, the upper image will belong to the right eye, and if this image is to the right of the lower image inward deviation of the visual axes is indicated. The prism, placed base out before the eye, that brings the two images in line indicates the degree of esophoria. If the upper image is to the left of the lower, exophoria is present and may be measured by the prism, base in, which brings them to their normal position.

In determining the insufficiency of the vertical muscles, lateral diplopia should be produced by placing a high prism 10 degrees, base in, before either eye, preferably the right. Orthophoria is indicated by the two images thus produced being on the same horizontal plane. If the image of the right eye is lower than that of the left, the visual axis of the right eye deviates upward, and the degree is measured by the prism place, base down, before the right eye, or base up, before the left eye that brings the images to their normal relation. This test fails to determine which eye is at fault in insufficiency of the vertical muscles.



ORTHOPHORIA

LEFT HYPERPHORIA *Prism base down left eye to correct.*

RIGHT HYPERPHORIA *Prism base up left eye to correct.*

FIG. 217.—MADDOX ROD TEST FOR HORIZONTAL DEVIATION WITH ROD BEFORE THE LEFT EYE.

A, the line passes through the flame—Orthophoria; *B*, the line passes below the flame—Left Hyperphoria; *C*, the line passes above the flame—Right Hyperphoria.

Stevens's phorometer is also of great value in determining disturbances of muscle equilibrium. It consists of two 4-degree prisms mounted in a frame which should be held about 3½ inches from the eye. The prisms are so placed that they can be rotated, and the character of the defect as well as its degree is indicated on a graduated scale at the periphery of the frame. The patient is directed to gaze upon a light at 6 metres distance through the prisms, which immediately give rise to diplopia. If the indicator points to the zero mark on the scale, orthophoria is present as regards the set of muscles being examined, and the two lights will be on the same plane. If the lights are not on the same plane, the prisms should be rotated until such is the case, the index now pointing to the degree of muscle disturbance. This instrument is inapplicable in very high degrees of heterophoria.

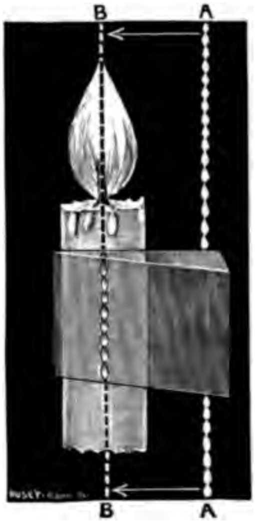


FIG. 218.—EXOPHORIA. Showing the effect of a prism base, in throwing the line *A-A* to *B-B*.

Owing to the confusion in the patient's mind which the light, ordinarily employed, sometimes induces, the author has designed a chart (Fig. 220) upon which it is very easy for the patient to fix his attention. It consists essentially of a dial, with a number of radii, from the periphery of which four lines extend, two vertical and two horizontal, corresponding to the principal diameters of the dial. The card containing the dial is placed at 6 metres distance from the patient and is properly illuminated. The phorometer is then placed before the eyes and two dials are seen. If the horizontal lines coincide and form one straight line and the indicator points to zero on the scale, orthophoria is present. If the two dials are side by side and their horizontal lines do not coincide, right or left hyperphoria is present. The prisms should be rotated until the relative positions of the two dials are the same as in orthophoria. The indicator on the phorometer shows the prismatic effect necessary to accomplish this or the degree of hyperphoria. If the images are one above the other, and the vertical lines do not coincide, esophoria or exophoria is present. The prisms are again rotated until the vertical lines form a long straight line. The degree and character of the lateral insufficiency can then be read from the scale on the phorometer.

Rotary prisms may be employed in conjunction with the Maddox rod-test to ascertain the degree of heterophoria. Risley's rotary prism is probably most commonly used in this connection. The principle is the same in all forms of this apparatus. It consists of two superimposed prisms of 15 degrees each, mounted in a milled-edge cell. A graduated scale is marked on the rim of the cell and a linear scratch on the prism serves as an indicator. A milled-edge wheel is placed at the periphery to facilitate the rotation of the prisms. When the indicator points to zero on the scale the prisms exactly neutralize each other, and their effect is that of a plane lens. Rotation increases their strength, so that when their bases are exactly superimposed a prism of 30 degrees is obtained.

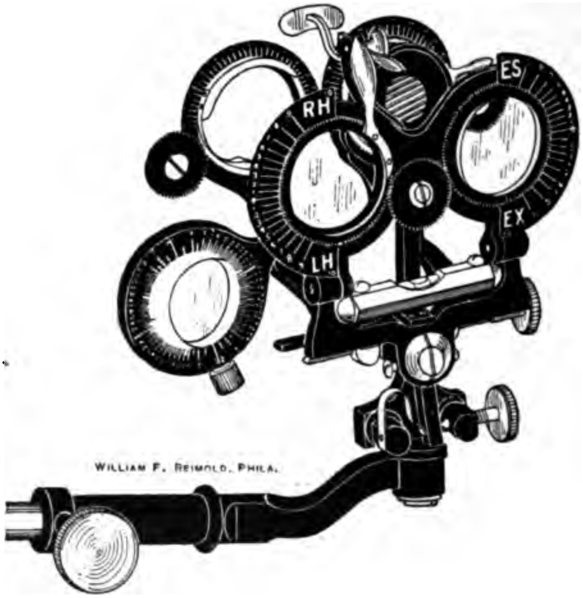


Fig. 219.—Modern Optometer and Phorometer.

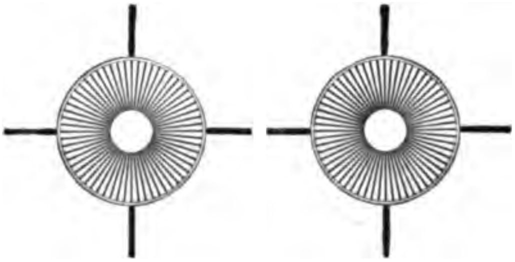


Fig. 220.—Dials used by the Author in Testing for Heterophoria and Astigmatism.

The line-and-dot test of von Graefe is not uncommonly employed to determine insufficiency of the lateral muscles at the ordinary reading distance. The patient is directed to look at a card containing a black dot through which passes a vertical line 3 inches long, at a distance of 13 inches. A prism of 8 degrees is placed base down before the right eye. Diplopia is produced, and the relation of the images indicates the muscle condition. In orthophoria the dots are directly over each other, and the two vertical lines form one long continuous line. Displacement of the upper image to the right indicates esophoria, and is measured by the prism necessary to restore the normal relation of the images. The reverse displacement indicates exophoria, and is measured in the same manner. Jackson's dot test is also of value.

The convex spherical test consists in placing a high convex spherical lens (15 D.) before one eye, having all but the optical centre covered. The patient is directed to look at a candle flame at 6 metres distance. Two images are perceived, one in the shape of a blur of light, the other the ordinary candle flame. If these coincide orthophoria is present. The relation of these images to each other is indicative of the muscle condition, as in the other test.

Insufficiency of the oblique muscles or **cyclophoria** is somewhat infrequent as an individual condition, but usually exists combined with some other form of heterophoria. It may be detected by the use of the Maddox double prism.

The eye under examination should be covered and the prism placed before the other eye. A card on which a horizontal line is drawn is held 18 inches from the eye and the patient fixes upon the line. Two lines are perceived by the action of the prism. The cover is removed from the first eye and three lines are seen, the third or new line being between and parallel to the other two lines if orthophoria is present. If there is any imbalance of the oblique muscles the third line will be tilted up or down. If the line is nearer the top than the bottom line hyperphoria is present, and if the line extends more to one side than the other there is insufficiency of the lateral muscles (Savage).

Heterophoria.—The symptoms produced by heterophoria are those of asthenopia of the muscular variety. Pain in the eyes, photophobia, headache, vertigo, car-sickness, etc., are pronounced in disturbances of muscle equilibrium, and while suggestive of heterophoria are by no means diagnostic. In all cases, the condition of the muscles should be noted as routine measure.

The treatment of heterophoria is influenced by a number of factors, all of which should receive consideration. As the condition owes its production in large part to some form of uncorrected ametropia, this error of refraction should be corrected immediately under the influence of a mydriatic, preferably atropine. The influence the accommodation exercises over the muscle balance may be easily ascertained by comparing the results of the muscle-tests obtained without a mydriatic with those obtained under mydriasis.

If the response to this part of the treatment is not prompt, and the condition persists, the general muscle-tone throughout the body should be improved by outdoor exercise, plenty of fresh air, the restriction of close work, tonics, etc., all of which contribute to the relief of the condition. Two classes of internal remedies suggest themselves when the symptoms are marked, namely, nerve sedatives, of which the bromides are types, and nerve tonics, represented by strychnine, arsenic, and nux vomica. The bromides are of temporary value in relieving distressed symptoms and affording a rest to the muscles when exhaustion is imminent. When the condition is one of mild fatigue the administration of small doses of strychnine or nux vomica is of great value in restoring tone to the muscles. Prism exercises are also of great value in heterophoria. In pronounced cases tenotomy or other muscle-operation may be performed.

In insufficiency of the adductor group of muscles, so common in myopic defects, the oculist has in addition to the correction of the ametropia a choice of three treatments: the prescribing of prisms, ocular gymnastics, the advancement of the internal recti or tenotomy of the external recti muscles.

In prescribing prisms, the degree required is obtained by the tests previously explained. The full strength is seldom prescribed, it is usually reduced one-third, and is divided between the two eyes, with bases in. Decentering the lenses may also be employed.

Exercises of the ocular muscles should be given a fair trial in all cases. An easy exercise is to have the patient fix the gaze upon the finger or other object held a short distance from the eye. The finger is brought close to the nose until diplopia is produced. In this manner convergence is stimulated and maintained until diplopia is produced. The frequent repetition of this procedure is of great value.

Another valuable exercise consists in overcoming prisms of increasing strength placed before the eyes, bases out. The correcting lenses should be worn, and the patient is stationed about one foot from a steady light placed at the level of the eye, towards which he is directed to look. A pair of weak prisms (about 5 or 10 degrees) is placed, base out, in a trial frame before the eyes. At this distance binocular vision is perfect. The patient is directed to walk backward, or the light is carried away until diplopia is produced. If this occurs inside of 6 metres the exercise is repeated with weaker prisms. When a distance of 6 metres is reached and perfect binocular vision is maintained, the prisms are raised and an attempt is made to fuse the double image seen. If this is successful, the exercise is repeated with stronger prisms. The exercise should be performed three or four times a day, and the strength of the prisms should be gradually increased.

Tenotomy and other muscle operations are of great value in this connection, but their description will be fully given under Muscle Operations. The prismatic exercises are very useful adjuncts to all operations upon the ocular muscles.

In insufficiency of the external muscles the ametropia should be corrected at first, and the eyes afforded a complete rest for ten days or two weeks by the instillation of atropine (gr. j to ℥j) When it is impossible to have this performed 1 drop of homatropine (gr. x to ℥j) or scopolamine in solution (gr. ½ to ℥j) should be instilled into the eye just before going to bed for several nights. This relaxes accommodation and convergence during the night and does not incapacitate the patient for his daily work. Prisms may also be prescribed, bases out, but exercises are of no value whatever. In high degrees operations upon the muscles have been advised.

In disturbances of the vertical muscles the full prismatic correction that relieves the symptoms should be prescribed.

In disturbances of the oblique muscles, rhythmic exercises is which high convex or concave cylinders are rotated before the eye "fixed" on a flame are of great benefit.

Strabismus, Heterotropia, or Manifold Squint.—A condition of inco-ordination of the ocular muscles in which the degree of insufficiency is too great to be overcome by increased muscular effort.

The visual axis of one eye only is directed towards the object. This is known as the fixing eye in contradistinction to the other or deviating eye. There is always a marked diminution in the visual acuity in the squinting eye. Correcting lenses usually improve the vision, but occasionally they will be found to have no effect whatever.

Varieties of Strabismus.—*Convergent strabismus* is a form of this condition in which one eye deviates inward while the other eye fixes upon the object. It is also known as internal squint and esotropia. It is the most common form of squint, and is usually associated with hyperopia, most marked in the squinting eye. The resultant diplopia is homonymous in character.

Divergent squint is the opposite condition; one eye fixes on the object and the other deviates externally. Exotropia and external strabismus are synonymous terms for this condition. Myopia is usually present in this form of strabismus.

Vertical squint or hypertropia is the form in which the visual axis of one eye deviates upward.

Monolateral or one-sided squint is the term applied when the squint is a constant condition of one eye only.

Periodic strabismus is a variety in which the deviation is only occasionally present in one eye. It is due to excessive close work, and precedes some other form of strabismus.

Alternating strabismus is present when the deviation is present alternately in each eye. The vision is usually equal in both eyes, but the changing of the squint from one eye to the other is probably due to employing one eye for distance and the other for close work.

Concomitant squint is characterized by free movement of the eyes in all directions, but an inability to " fix " is manifested by one eye, giving rise to inward or outward deviation.

Spastic squint is a form resulting from a spasmodic contraction of one or more muscles. It is a rare condition. Spasm of accommodation is occasionally attended by internal strabismus, transitory in character, due to a more or less spastic condition of the internal recti muscles.

Paralytic squint is distinguished from the other varieties by a restriction of movement in one or more directions owing to a palsied condition of one or more muscles.

Causes.—The causes of squint are various, but for convenience in description they may be grouped in three classes: errors of refraction, anatomical peculiarities, and blindness.

In the *first class* belong those cases which, by reason of hyperopia or myopia, internal or external squint has taken place. The relation between these forms of ametropia and the extra-ocular muscle-balance has already been described at length in a preceding chapter. In cases due to high errors of refraction diplopia is produced, but the false image becomes blurred and suppressed in a short time. If appropriate treatment is not promptly instituted, the function of the retina is to a great extent lost and *amblyopia exanopsia* or blindness from disuse follows. It is to this class of cases, therefore, that treatment offers the greatest hope for cure.

In the *second class* may be included the peculiarities of the face and orbit that allow or restrict freedom of movement of the eyeballs. In this class may also be placed anomalies in shape, size, and attachment of the ocular muscles.

The *third class* consists of blindness, congenital or acquired. A blind eye is incapable of "fixing" upon an object on account of the afferent impulses not being carried to the centres in the brain. In congenital amblyopia the eye-ground is not in condition to transmit impulses, and in the acquired form it is unable to receive them, owing to various opacities in the dioptric system, such as maculæ, leucoma, cataract, vitreous opacities, etc.

To determine the presence and degree of strabismus, the tests described under heterophoria may be employed, but on account of the reduced sensibility of the retina of the deviating eye they may be very unsatisfactory. Owing to the fact that the sensitiveness of the nerve-tunic is retained in large part for red, a plane red glass placed before the squinting eye may serve to bring out the false image.

The cover test as employed in heterophoria is also of great service in this connection. The degree and character of the squint may be easily determined by noting the primary and secondary deviation.

The strabismometer has been extensively employed to estimate the deviation of the eyes in strabismus, but is seldom used at present on account of its inaccuracy. It consists of a piece of ivory hollowed on one side to fit the curve of the eyeball, on the edge of which is marked a graduated millimetre scale. The instrument is held to the eye so that the zero mark on the scale corresponds to the centre of the pupil while the eye "fixes" on some distant object. The eye is then covered and the other eye fixes on some close object. As the first eye is uncovered its deviation is noted, each degree on the scale representing 5 degrees deviation.

The most accurate of all tests for estimating the degree of strabismus is the perimeter test. The patient is seated in front of this instrument so that the squinting eye is directed towards the centre of the instrument. Both eyes should then be directed towards some distant object in the median line opposite the patient. The arc of the perimeter should be placed horizontally and a candle-flame, placed first at the fixation point, should be brought out gradually on the inner surface of the arc until the eye of the observer, directly back of the candle-flame, can see its image in the pupillary centre of the squinting eye. The number registered on the arc at this point indicates the degree of deviation.

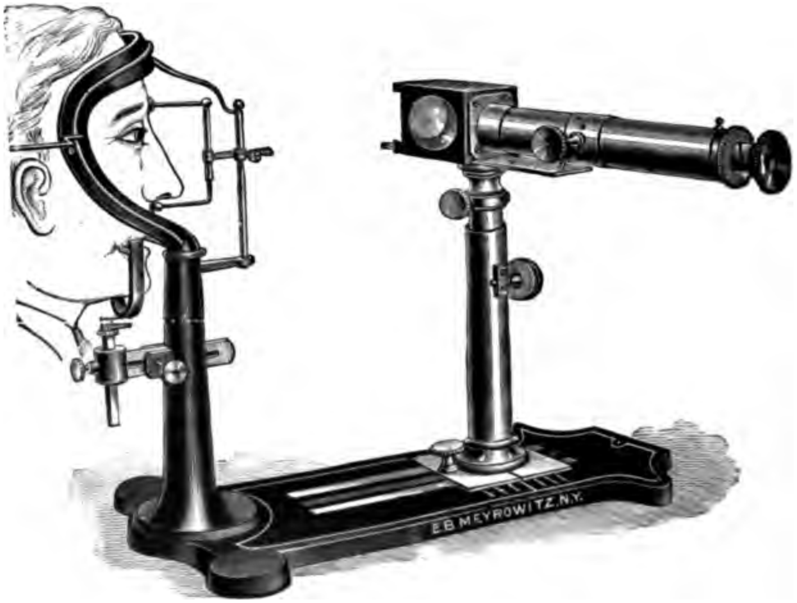

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FIG. 221.—STEVENS'S TROPOMETER.

Stevens's Tropometer.—An instrument for the determination of the various ocular rotations. It consists of a telescope mounted upon a suitable stand with a head-rest for maintaining a primary

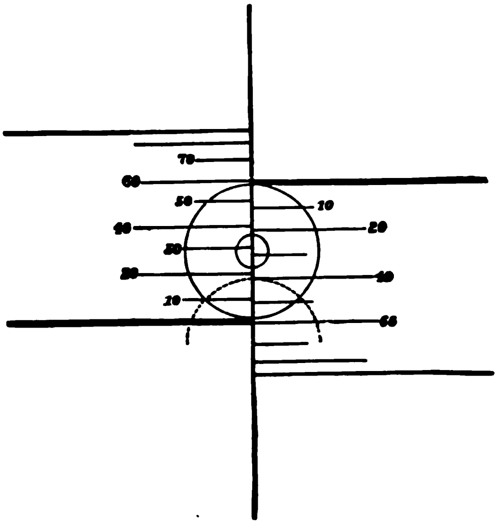

Fig. 222.—Scale on Tropometer.

position of the patient's head. An adjustable stirrup is provided for this purpose, and the bulbous extremities of two guiding rods indicate when this position has been attained. The upper rod should be in contact with the face at the glabella above the root of the nose, while the lower should be placed at the centre of the upper lip. The patient is then instructed to gaze directly at the instrument, and an image of the eye is reflected by a mirror or refracted by a prism down the barrel of the telescope, so that the observer seated at one side of the patient views an indirect image of it.

The instrument is provided with a scale which consists of a long line, between and at right angles to shorter lines, that divides it into two similarly graduated scales running in different directions. In any examination the primary position should be such that the outer border of the cornea when viewed through the telescope should be in contact with two strong lines representing the zero mark on each scale. The rotation of the eye will be indicated by a change in the relative position of the outer border of the cornea and strong lines, and as the interval between each pair of short lines is 10 degrees, the exact degree of rotation may be easily ascertained by the reading of the scale. For the measurement of the horizontal, vertical, and oblique rotations the scale may be placed accordingly. According to Stevens, the normal rotations are:

Upward, 33°; downward, 50°; inward, 55°; outward, 50°.

Symptoms.—The symptoms of strabismus are few in number. Asthenopia is seldom present except in the beginning, and offers no guide to its detection. Diplopia is also infrequent for the reasons already given. The cosmetic disadvantage is perhaps the most annoying symptom. Although vision is greatly reduced, it is frequently unnoticed.

The treatment of strabismus includes the correction of the existing ametropia, surgical operations upon the muscles, and prism exercises. The ophthalmic surgeon is often consulted for the first time to remedy the condition for cosmetic purposes, both patient and his friends being woefully ignorant of the reduction of visual acuity in the "crossed" eye. This is particularly true of children in whom the condition is attributed to all sorts of impossible diseases.

Bearing the causes of strabismus in mind, it is obvious that in most cases the eye should be placed at prolonged rest under the influence of atropine. The employment of homatropine and other rapid-acting cycloplegics in this connection defeats their purpose on acount of the short duration of their effects. The refraction should be examined into frequently, and before the mydriatic has lost its effect the correcting lenses should be prescribed and worn constantly. The retinoscope finds its greatest field of usefulness in this condition on account of the obtunded sensibility of the retina in the squinting eye, it being often impossible to distinguish the largest letters on the test-cards.

Not infrequently the squint disappears by the instillation of atropine alone, and less commonly it reappears when accommodation is once more established. Such cases require prolonged cycloplegia with the constant wearing of dark glasses during this period.

A very efficient exercise for bringing the squinting eye to fixation is the blinder exercise. The better eye should be covered for a period of fifteen to thirty minutes three or four times daily. The correcting lenses should be worn and the blinder placed before the good eye. This is least annoying if performed while eating the meals. The prognosis with this treatment in young children is extremely gratifying.

Worth Amblyoscope.—For the exercising of the fusion faculty in young children the subjects of strabismus, Worth has devised an instrument to which he applies the term "amblyoscope." It consists of two halves joined by a hinge, each of which is made up of a very short tube joined to a longer one at an angle of 120 degrees. A mirror is placed at the free end of the long tube, and a lens the focal length of which is equal to the distance of the reflected image of the object-glass is placed at the free end of the shorter tube. The hinge allows changes in the relative position of the two halves, so that the instrument may range in its adaptability from 60 degrees of convergence to 30 degrees of divergence. The object-glasses are covered by translucent paper on which may be figures of 3 classes: 1. Bird and a cage, mouse and trap, etc. 2. Figures incompletely made on each slide, so that fusion of the images is necessary to perceive the entire object. 3. Stereoscopic pictures.

In the application of the instrument the child should wear the proper correction and the object-glass of the first class should be employed. The patient should be directed to put the bird in the cage or the mouse in the trap. Each tube should be illuminated by a portable lamp placed in its axes and about 4 feet from it. The object before the better eye is seen immediately, but that before the other eye is not perceived at all. The lamp in front of the object best seen is moved away and the other lamp is brought closer to its corresponding tube until the other object is seen. The intensities of the illumination are then adjusted so that both objects are seen. The angle of the instrument is changed so that

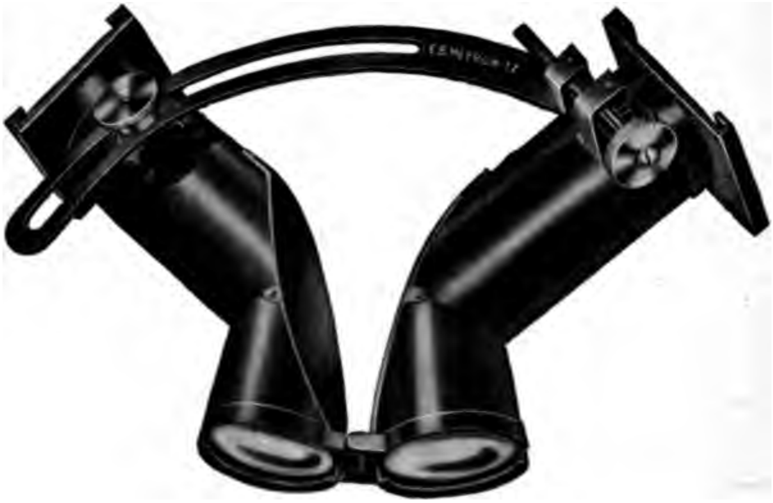

FIG. 223.—WORTH AMBLYOSCOPE.

fusion occurs. As the fusion becomes more developed the angle of the tubes may be varied considerably.

In adults, correction of ametropia, prisms, and prism exercises may be tried, but the success attending such procedures alone is not very encouraging. Tenotomy, advancement, or other operation upon the muscles at fault is usually necessary. Operative interference, however, should always be preceded by a careful examination of the defective eye in every particular, and followed by prism exercises and examination of the refraction.

Paralysis of the Ocular Muscles.—An impairment of the function of one or more ocular muscles is known as *paresis;* absolute loss of function, temporary or permanent, is termed *paralysis.* The latter may be congenital or acquired.

Congenital paralysis attacks the levator palpebræ superioris, most often giving rise to ptosis or drooping of the upper lid. Impairment of the function of the external rectus may also be congenital, but is less frequent.

Acquired paralysis results from general diseases which affect the nerves supplying the muscles in some part of their course from the cortical centres of their distribution in the muscles themselves. The tertiary manifestations of syphilis and tubercular meningitis are perhaps the most common causes. It is frequently associated with locomotor ataxia and general paralysis of the insane. Blood-clots, tumours, abscesses, aneurysms, head injuries, fracture of the skull, etc., may also induce the condition by pressure upon the nerves or nerve-centres. The infectious fevers, particularly diphtheria and influenza, are important ætiological factors. Less frequently the affection arises from the toxins of rheumatism, tuberculosis, diabetes, typhoid fever, nephritis, etc. Exophthalmic goître is also said to be an occasional cause. Among the more remote factors in its production may be mentioned tobacco, alcohol, lead, ptomaines in decomposing food, carbon-dioxide gas, hysteria, and exposure to cold.

Acquired paralysis may be complete or partial. Total ophthalmoplegia consists of loss of function of all the ocular muscles, and results from some very serious condition of the brain. Partial paralysis is confined to one or more sets of the muscles of the eye. It may be divided into internal and external ophthalmoplegia.

Internal ophthalmoplegia is an infrequent condition in which the ciliary muscles and the circular and radiating fibres of the iris are involved. Palsy of the ciliary muscles alone is not so rare, and is most common after diphtheria and the instillation of mydriatic drugs.

External ophthalmoplegia consists of suspension of function in the four recti and two oblique muscles of the eye. When the paralysis involves all these muscles at the same time, locomotor ataxia is usually the cause. Partial external ophthalmoplegia is the most common form of ocular paralysis and is manifested by strabismus.

This form usually arises from involvement of the nerves supplying the muscles, but may be due to some disease of the muscles themselves. The third cranial or oculomotor nerve, if its function undergoes any alteration, induces palsy of the levator palpebræ, the superior, inferior, and internal recti, the inferior oblique, the sphincter pupillæ, and the ciliary muscle. Impairment of the sixth nerve results in loss of function in the external rectus muscle. Any pathological condition of the fourth cranial nerve induces palsy of the superior oblique muscle.

Symptoms.—One of the most prominent symptoms of paralysis is the limitation of motion corresponding to the palsied muscle. It is most marked when the patient attempts to follow the movement of some close object by the eyes alone. This limitation will also bring out another symptom, that of squint. This is present only when the eyes are moved in the direction of the paralyzed muscle. Movement in the opposite direction being normal, the deviation of the squinting eye is in a direction opposite to that of the affected muscle, and is known as primary deviation. If the squinting eye "fixes," the sound eye will deviate in a corresponding direction but to a greater degree. This is known as secondary deviation. This difference is of importance in distinguishing paralytic squint from concomitant strabismus, in which the primary and secondary deviation are equal.

There is always more or less false projection of images, as is indicated by the failure to locate objects properly, and from this naturally arises uncertainty in gait and inco-ordination of other movements of the extremities.

The patient complains also of double vision or diplopia when looking at objects within the sphere of action of the paralyzed muscle. This is increased by movement of the eyes in the direction of the affected muscle and decreased by movement in the opposite direction. In order to assist in diminishing the diplopia, the patient unconsciously turns the head obliquely towards the side corresponding to the palsied muscle.

Other subjective symptoms deserving mention are nausea, vomiting, mental confusion, a sense of insecurity, etc., all of which are greatly relieved by occluding the affected eye by a blinder.

The characteristic symptoms disappear to a great extent, as the duration of the palsy increases, even when the function is not re-established. The patient becomes accustomed to the diplopia and the false image is more or less blurred and suppressed. As a late result contraction of the opposite muscle is greatly increased and the squint becomes more pronounced than formerly.

The diagnosis is made by the limitation of motion and the position and relation of the images to each other. The placing of a red glass before the squinting eye will cause the false image to be coloured and the examination will be greatly facilitated.

Paralysis of the external rectus is characterized by limitation outward, convergent strabismus, and turning of the head towards the paralyzed side. If the patient looks towards the paralyzed side homonymous diplopia is produced. The images are on the same level, and the false image is in the central portion of the field. Turning of the eyes towards the palsied muscle increases the lateral separation. This form of ocular paralysis is the most frequent, forming about one-third of all such cases.

Paralysis of the internal rectus is attended by limitation of movement inward. Diplopia is produced when the patient looks towards the affected side, and is heteronymous or crossed in character. Adduction of the sound eye increases the distance between the images, which are always on the same level.

Paralysis of the superior rectus is manifested by a change in the relative positions of the images in addition to their crossing. The false image is above and inclined away from the true image. This inclination is increased by looking towards the sound eye.

Paralysis of the inferior rectus is also attended by an alteration of the images in their relation to each other. The false image is below and inclined towards the true image. The diplopia present is of the crossed variety.

Paralysis of the superior oblique is the second most frequent isolated paralysis, constituting about one-sixth of all the ocular paralyses. The diplopia is homonymous in character and the images are one above the other. The false image is below and inclined towards the true image. Downward rotation is lessened.

Paralysis of the inferior oblique gives rise to homonymous diplopia, in which the false image is above and inclined somewhat outward from the true image.

Total ophthalmoplegia is manifested by crossed diplopia. The situation of the images is peculiar, the true image being vertical while the false is slightly above and its upper end is inclined towards the true image. Mydriasis and ptosis accompany this affection.

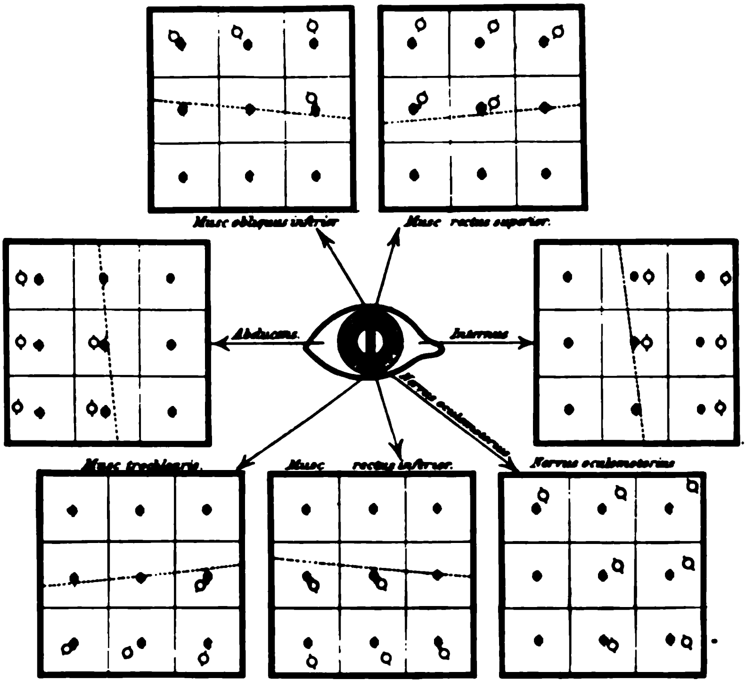

FIG. 224.—SHOWING IMAGES IN OCULAR PALSIES (RIGHT EYE); RED IMAGE IS THAT OF THE UNPARALYZED EYE.

Prognosis.—In nearly all cases the duration of the condition extends over a long period. An exception to this occurs in the case of acute total ophthalmoplegia, in which a fatal termination takes place in a short time from the structural changes in the central nervous system. Chronic total ophthalmoplegia is unfavourable as to cure of the ocular paralysis, but the duration of life depends upon the progression of the central disease. Isolated paralysis of short onset following the infectious fevers, such as diphtheria, recover most rapidly. Occasionally an hysterical history can be elicited, and in such cases response to treatment is prompt. Paralyses the result of injury are always of doubtful prognosis. In other cases, if the presence of syphilis can be proved and the affection promptly treated, the muscle regains its function after a period of several months. Organic disease of the brain or spinal cord always influences the prognosis unfavourably. In long-standing, untreated cases the paralyzed muscles tend to atrophy from disuse and the opposing muscles undergo contraction from lack of resistance. Relapses are frequent.

Treatment.—This may be constitutional or local. In those cases in which constitutional affections, such as syphilis, gout, rheumatism, etc., are found to be the causal factors the appropriate treatment should be instituted, attention being paid to the most minute detail. Even in the absence of a clear history of syphilis or rheumatism the administration of mercury and the iodides, alone or combined, is productive of beneficial results. If the paralysis is secondary to some infectious fever, such as diphtheria, strychnine in ascending doses will be of great value. The functional paralyses such as occur in hysteria are improved by the ordinary methods employed in the treatment of functional nerve disorders elsewhere in the body.

The local treatment includes electricity, ocular gymnastics, prisms, occlusion of the squinting eye, and muscle operations.

In using electricity the constant current is most often employed. The positive pole should be applied to the back of the neck and the negative pole directly over the affected muscle. In the beginning the strength of the current should not be over 1.5 milliampères, otherwise annoying flashes of light will be experienced by the patient. Later the current may be increased to 3 milliampères.

Ocular gymnastics, in this connection, consist largely in allowing the patient to wear prisms that almost correct the diplopia. An attempt is then made by the paralyzed muscle to overcome the remaining portion. An increase in the ability to do this is a favourable indication. Another exercise consists in moving the head until the images are fused, and then attempting to bring about the same result without moving the head. To derive any permanent benefit from these exercises it is necessary to repeat them carefully eight or ten times daily.

Prisms may be prescribed and worn constantly to overcome the diplopia, but on account of the weight and attendant chromatic aberration in the high degree prisms necessary for this purpose they are frequently discarded by the patient.

A simple method of treatment consists in occluding the paralyzed eye from partaking in vision by means of a clinder, patch or bandage. This prevents the annoyance occasioned by the diplopia, but in no manner hastens recovery.

Among the muscle operations advised for ocular paralyses may be mentioned muscle-stretching, tenotomy, and advancement alone or combined. They are best adapted to obstinate cases and frequently their only result is cosmetic in character.

Nystagmus.—An affection involving the motility of the eyeballs manifested by rapid involuntary oscillations of those organs. It is bilateral in character. The movements are jerky and spasmodic, and do not replace the normal movements of the eyes, but accompany them. The movements may be lateral, vertical, oblique, or rotary in direction, and are often attended by corresponding movements of the head. Imperfect vision and disturbances of the extra-ocular muscle balance are frequently associated with the condition. The lateral form is most common.

Among the causes of nystagmus may be mentioned opacities in the dioptric system, intra-ocular diseases, albinism, coloboma, aniridia, congenital cataract, microphthalmus, retinitis pigmentosa, errors of refraction, and disseminated sclerosis. An interesting variety is that found in coal miners, in whom it is probably developed by constant strain in darkness and by the semi-recumbent postures they are forced to assume while at work.

Miners' nystagmus is most amenable to treatment, the affection disappearing as the patient changes his occupation. In other cases nothing is of value except possibly the correction of errors of refraction. Sometimes the affection is choreiform in character, disappearing during sleep and as age advances.

NORMAL DECLINATIONS OF THE RETINAL MERIDIANS

That the retinal meridians are subject to normal deviations was first pointed out by Dr. George T. Stevens, of New York city. He defines normal declinations of the retinal meridians as a deviation of the vertical, horizontal, or any given meridian of the eye from the corresponding meridian of external space, when the line of regard of the eye is directed parallel to the median plane and in the horizontal plane, the head being exactly erect or, more technically, in the primary position. The following diagram of Stevens serves to explain this definition very well.

The equator of the eyeball is represented by the circle *e a c, f b d,* and the line *a b* represents the normal position of the vertical meridian of the eye. When this line corresponds with the vertical meridian of surrounding space there is an entire absence of declination, but if it deviates to either side by a rotation upon its antero-posterior diameter, the meridians no longer correspond with those of external space, and declination is present. When the top of the meridian line, *c d,* inclines towards the temple it is known as ***positive*** or (+) declination, but if the top of the line, as *e f,* leans towards the nose it constitutes negative or (—) declination.

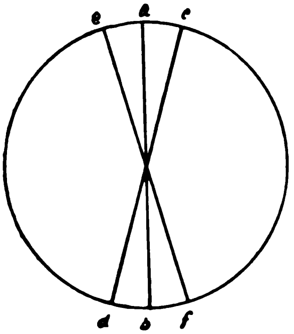

Fig. 225.

Declinations of the meridians may be physiologic or pathologic. Physiologic declination is the common form and may be regarded as an anomalous condition. It probably results from variations in the size and shape of the orbit and the insertions of the extra-ocular muscles. It is also known as normal declination.

Pathologic declinations are those that follow insufficiency, paresis, or paralysis of one or more ocular muscles, as the result of disease or injury.

Many of the *symptoms* associated with normal declinations are similar to those attributed to heterophoria. One of the manifestations is dryness of the eyelids with the sensation of a foreign body within them. There is often chronic hyperæmia of a most persistent type, which is undoubtedly due to pressure of the lids against the eyeball in an effort to steady the globe and resist any tendency to roll incident to the declinations of the meridians. The patient also complains of long-continued pain over one or both eyebrows. Inspection under such circumstances often reveals undue arching of one or both brows, and the pain is attributed to muscular effort on the part of the brow muscles in fruitless attempts to overcome declinations. Changes in the contour of the brows are in a great number of instances indicative of and directly due to normal declinations of the retinal meridians. Visual disturbances may also be traced to this same cause, and Dr. Stevens states that the amblyopia, that is not infrequently found in apparently well eyes in which there is no squint, is produced by this declination of the meridians. Asthenopic symptoms also attend this condition, and are particularly well marked in the presence of ametropia and heterophoria. The habitual pose of the head is subject to characteristic alterations in declinations. Double positive declination is marked by the head being thrown backward. This is often associated with pains at the base of the skull, over the spine of the seventh cervical vertebra, and between the shoulder blades. Vertigo and epileptoid attacks are also encountered. More frequently than the foregoing may be mentioned insomnia, nervousness, dyspepsia, neurasthenia, etc.

The relation between heterophoria and normal declinations is of importance in explaining some of the otherwise obscure phenomena associated with muscle insufficiency. In exophoria there is usually positive (+) declination of both eyes, which is almost equal in each. In hyperphoria, a declination of several degrees may be found in one eye, while the other will be either without declination or with very little, and usually of the same sign as that of the first eye. In esophoria declination is almost uniformly found in both eyes, and the leanings of the meridians are homonymous, as, for instance, if the declination is positive for the right it is negative for the left.

The relation between heterotropia or strabismus and declination is similar to that between heterophoria and declination, but the declination is of greater degree.

The presence and degree of declination can only be satisfactorily determined by means of the clinoscope devised by Dr. Stevens. It consists essentially of two hollow tubes; at one end of each is a pinhole opening through which the eye looks, and at the other end is a translucent disk on which a straight vertical line is drawn. One disk has the line drawn from the centre straight up to the periphery, while the other disk has the line drawn down from the centre to the periphery (Fig. 227). As it is necessary to maintain the tubes in the same horizontal plane, the attached spirit level is essential. The tubes rotate on their long axes and a pointer attached to each tube indicates on a scale the extent to which the tube is rotated. The extremities containing the sight-holes may be adjusted so as to suit the interpupillary distance in different individuals. Clips are also provided for holding the correcting lenses during the examination, as the patient should not wear glasses when this instrument is used. The sight openings should be small and on the same horizontal plane.

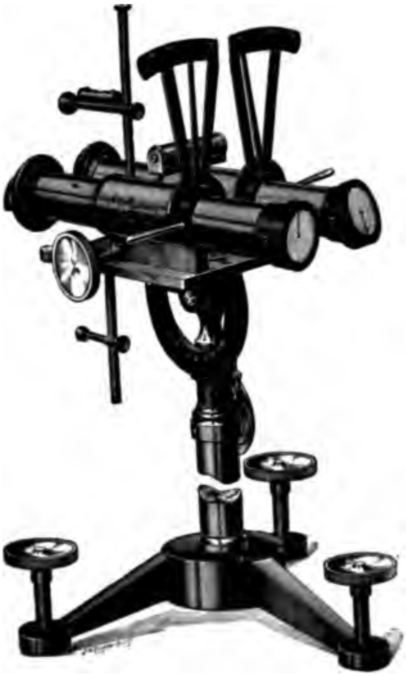

FIG. 226.—CLINOSCOPE.

In using the instrument the patient should sit erect and the sight-holes should be adjusted to the level of the eyes while in this position. The tubes may be parallel, or in exceptional cases may be made to converge for a distant point situated at eight or ten feet from the patient. The tubes should be on the same horizontal plane. When the examined patient has secured a good view of both the test-lines he should endeavour to unite them if

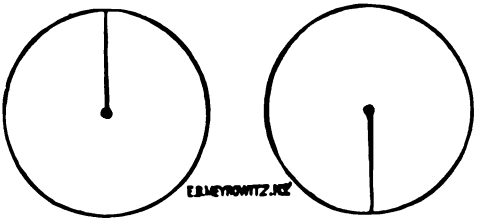

FIG. 227.—OBJECTIVE LINES OF CLINOSCOPE.

they do not at once unite, as in using a stereoscope. This is sometimes impossible and renders the examination somewhat less satisfactory in its results. When the apparent vertical position of the lines has been obtained, the examiner should move them more or less backward and forward in order that the true position may be more positively located. Two or three tests on different days are usually necessary before the patient is able to arrive at a satisfactory conclusion concerning the situation of the lines. The rotation of the tubes necessary to bring the lines vertical or horizontal indicates on the scale the degree of declination of the meridian under examination.

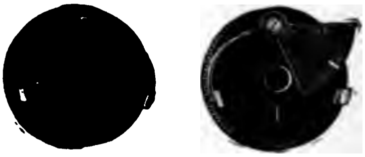
FIG. 228.—ENDS OF CLINOSCOPE TUBES.

Treatment.—Owing to the fact that tilting of the retinal images is easily induced by the improper adjustment of glasses, great care should always be exercised in fitting and centering of glasses. Other cases are amenable only to surgical treatment. Peritenotomy and extendo-contraction in which the line of insertion of the tendon of either of the recti muscles is advanced are the operations preferred by Stevens, who was the first to point out the true nature of this condition. In a number of cases great relief is afforded by directing the treatment to the underlying conditions, such as ametropia, heterophoria, and heterotropia.

MUSCLE OPERATIONS

The principal operations performed upon the extra-ocular muscles for errors of co-ordination are muscle-stretching, tenotomy and advancement.

Muscle-stretching is an operation devised for the relief of the squint in obstinate cases of ocular paralysis. The conjunctiva overlying the paralyzed muscle is grasped by means of fixation forceps, and the eyeball is forcibly rotated several times towards the affected side. This relaxes the contraction of the opposing muscle and prevents the formation of adhesions. The relief afforded by this procedure requires its repetition to be of value. Marked contraction of the opposing muscles is always an indication for its performance.

Tenotomy consists in severing the stronger muscle at its attachment to the eyeball. It is indicated in marked cases of squint, and may be performed alone or in combination with advancement. There are two methods: the open (Graefe's) and the subconjunctival (Critchett's). In either operation the surgeon should be provided with the following instruments:

Eye speculum.
Fixation forceps (Fig. 239).
Stevens's scissors.
Pointed strabismus scissors (English model).
Strabismus hook, English model or Stevens's.
Needle-holder, needles, silk, tray.

In the open method the eye is anæsthetized by the instillation of a 5-per-cent cocaine solution, one drop every five minutes for twenty minutes preceding the operation. The conjunctival *cul-de-sac* should be irrigated with a warm boric-acid solution to render the eye as aseptic as possible. In this as in other ophthalmic operations the surgeon's hands should be well cleansed and rendered aseptic by immersion in alcohol or other germicidal solution. The placing of the instruments in alcohol (alcohol ʒij, aqua destil. ℥vj) for a period of fifteen to thirty minutes renders them sterile without destroying the edges or inducing rusting. Purulent inflammation of the conjunctiva or lacrymal apparatus is a contra-indication to any operation of this kind. Children under ten years of age should never be subjected to any muscle operation.

After the preliminary preparations have been completed the patient should lie flat upon the back upon a suitable table and the eye speculum is introduced to hold the eyelids apart. The patient is directed to look straight out so that the relations of the various structures may not be disturbed. The conjunctiva over the lower portion of the muscle at its insertion is incised about 2 to 4 millimetres from the corneal margin, and is dissected backward and downward beyond the lower border of the muscle, thereby exposing it. A strabismus hook is introduced beneath the muscle, which is then raised and divided near the sclera.

In the subconjunctival method the eye is prepared in the same manner and the eye speculum is then introduced. The conjunctiva, subconjunctival tissue, and Tenon's capsule overlying the lower portion of the muscle's insertion, is grasped by fixation forceps and raised, after which they are divided horizontally by scissors.

The fold of conjunctiva is raised and a strabismus hook is introduced beneath the muscle. The hook is then raised so that the tendon of the muscle is brought to the wound in the conjunctiva. The tendon is divided close to the sclera and the hook is inserted once more to make certain that the division of the tendon has been complete. The ordinary hæmorrhages encountered may be controlled by sponging, cocaine, or adrenalin (1 to 1,000).

Inflammatory reaction seldom occurs and may be lessened by the application of iced compresses for ten or fifteen minutes every three hours. The position of the eyes should be noted immediately after the operation as well as subsequently, as the effect of the operation may be in excess of the result desired. When the immediate result is perfect, divergence usually follows at a later period, so that convergence should not be entirely absent directly after the operation to obtain a permanent satisfactory result. The placing of the eyes at rest for a few days prior to the operation by the instillation of atropine and the use of an occlusive bandage aids the efficiency of this procedure materially.

In graduated tenotomies a small vertical opening is made in the conjunctiva, the muscle is seized near its insertion, and a small central opening is made dividing the tendon on the sclera. This may be enlarged according to the judgment of the surgeon, but the muscle is never completely divided. These operations are employed in lower degrees of squint than the preceding methods (Stevens).

Advancement.—The operation of advancement is intended to increase the power of the muscle to move the eyeball by advancing its attachment. The weaker muscle is always selected. It may be performed alone, but is productive of better results when combined with tenotomy. The preparations for this operation are much the same as in tenotomy.

The instruments necessary are the same as those used in tenotomy. After the eye speculum has been introduced a vertical incision 10 millimetres in length is made in the conjunctiva midway between the cornea and the insertion of the muscle. The underlying attachments of the conjunctiva are freed over the tendon. An incision is made in Tenon's capsule at the lower border of the muscle, and a hook is introduced through this opening beneath the muscle, which is then freed of all its attachments to surrounding structures. This is followed by the passing of three strong sutures through the muscle from behind forward; one through the centre of the muscle, one near the upper margin, and one near the lower margin. The introduction of these sutures should be such as to include the capsule of Tenon and conjunctiva with the muscle. The tendon should then be divided near its insertion, or a portion excised according to the judgment of the surgeon and the effect desired. The central suture is continued beneath the conjunctiva, passes through the more superficial layers of the sclera, and emerges at the margin of the cornea in its horizontal meridian. The upper and lower sutures pass obliquely beneath the conjunctiva above and below the cornea. The outer layers of the sclera are transfixed by the sutures, which finally emerge at the upper and lower corneal margins respectively in the vertical meridian. The eyeball is then rotated inward, so that the degree of advancement necessary may be ascertained, and the sutures are tied while the eye is in this position. A few interrupted sutures are used to close the conjunctival wound, after which the eye is bandaged and the patient placed at rest in bed for a day or two. Inflammatory reaction may be controlled by cold compresses and irrigation with boric-acid solution. The sutures should not be removed for one week at least, unless

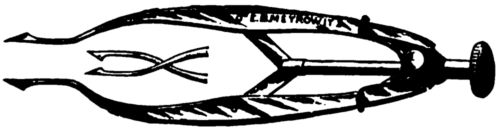

FIG. 229.—TODD'S TENDON TUCKER.

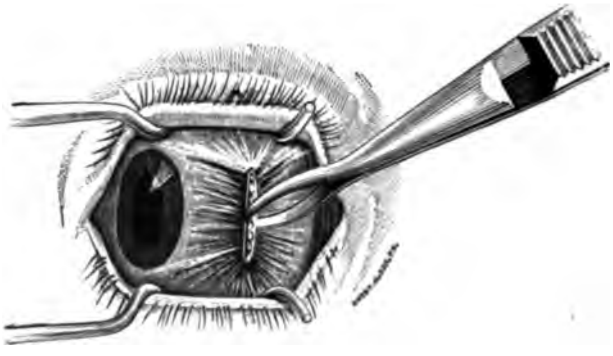

FIG. 230.—AUTHOR'S OPERATION FOR DIVERGENT SQUINT. (First stage)

it is desired to diminish the effect of the operation. Overcorrection is necessary at all times to obtain a perfect result in the end.

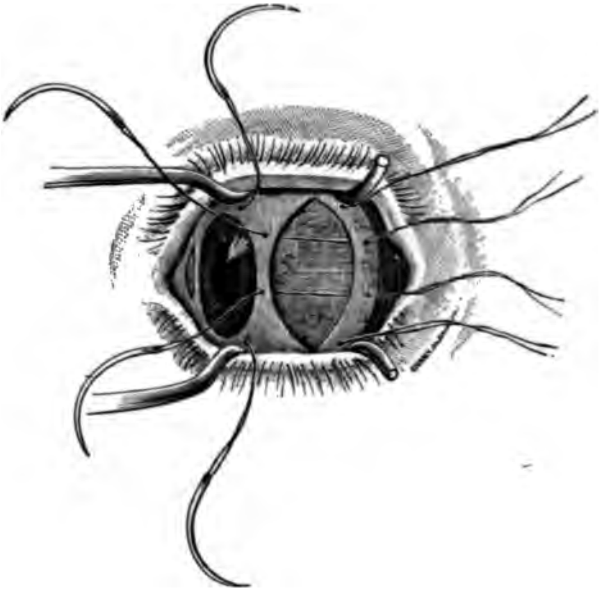

FIG. 231.—AUTHOR'S OPERATION FOR DIVERGENT SQUINT. (Second stage.)

Capsular advancement is an operation employed in the lower degrees of squint, and consists in shortening or advancing the capsule of Tenon over the affected muscle.

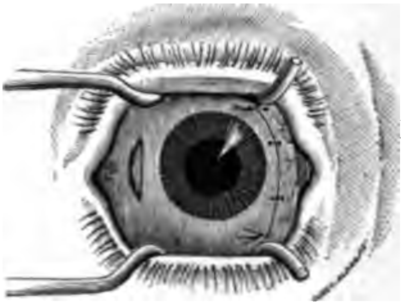

FIG. 232.—AUTHOR'S OPERATION FOR DIVERGENT SQUINT. (Completed.)

An ingenious instrument for shortening the muscle is the "tucker" devised by Todd. It consists of a pair of spring forceps, the lower ends of which are so formed as to cross each other, and separate when the forceps are closed and maintained so by a screw attachment. The upper and crossed prong is inserted beneath the muscle, while the lower prong is above that structure. As the spring is released the prongs of the instrument approach and pass each other, forming a fold or tuck in the muscle. Catgut sutures are passed through and through the muscle to fasten it on itself, and silk sutures are employed to secure the muscle loop to the conjunctiva and episcleral tissue.

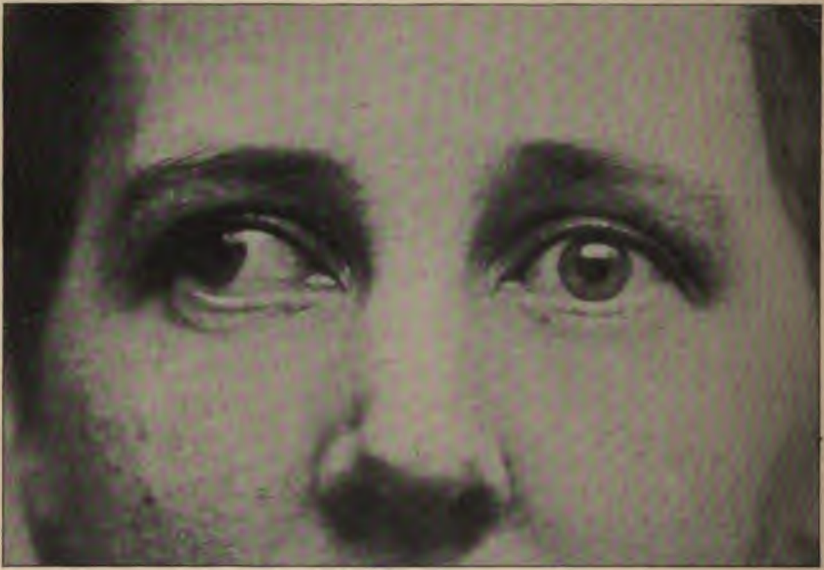

FIG. 233.—DIVERGENT SQUINT BEFORE OPERATION.

The muscle-balance should be taken frequently after all these operations. The full correction of any error of refraction should be prescribed and worn constantly, and prism exercises should be regularly performed.

Author's Operation for Divergent Strabismus.—In divergent strabismus the following operation has given the best results in the author's experience; it is best adapted to cases in which the deviation is 5 millimetres and upward.

The operation is divided into three parts, and is performed under cocaine: (1) Tenotomy of both external recti muscles and stretching of conjunctiva and Tenon's capsule; (2) making the elliptical opening either on one eye or both; (3) suturing this opening.

The details of the operation are carried out as follows:

1. Tenotomy of both external recti muscles, making an opening through the conjunctiva, over the insertion of the tendons. I then stretch Tenon's capsule until the cornea is well into the inner canthus—this is done on both eyes. The stretching of Tenon's capsule is an important part of the operation, and should be performed as follows: The strabismus hook, which is a large one, flat on its side, is inserted in the opened conjunctiva and Tenon's capsule, and with considerable traction all the tissues are stretched inward until the cornea is buried in the inner canthus. The stretching of the upper tissue has, as can be readily understood, a tendency to rotate the eyeball to a certain degree and leave the conjunctiva and Tenon's capsule intact below; to equalize the stretching, the point of the hook is reversed, and the lower conjunctiva and capsule stretched.

2. With the retractor forceps I grasp the conjunctiva vertically, midway between the cornea and caruncle and directly over the internal muscle, and draw upward the conjunctiva and as much of Tenon's capsule as I can. I raise the forceps two or three times to take up as much of the redundant tissue as my

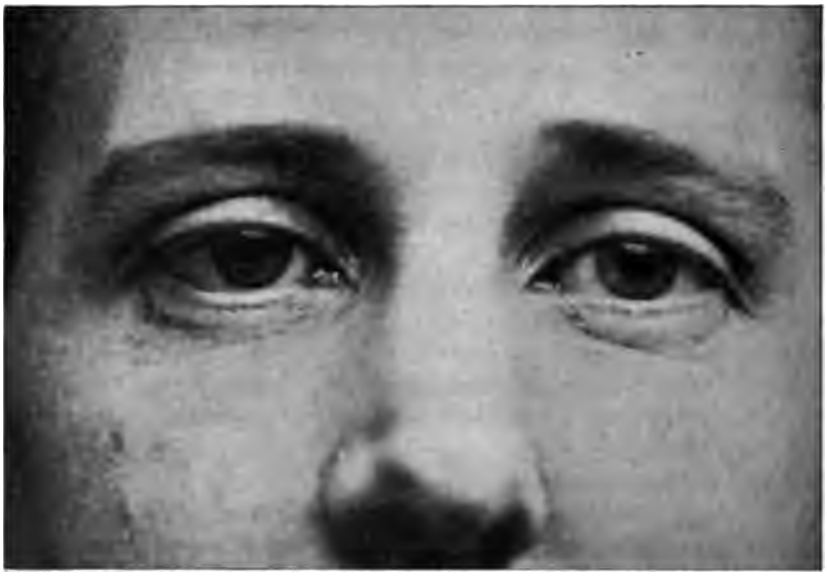

FIG. 234.—AFTER OPERATION.

judgment dictates, and by this means one apparently is always successful in separating conjunctiva and overlying tissue from the muscle, if it be still present; then with curved scissors I cut with one long sweep the upraised conjunctiva and capsule close to the eyeball, making an elliptical opening, exposing at times the attenuated muscle, and, if no muscle be present, then the clear sclerotic.

This opening now extends in a vertical direction, beginning below the lower level of the cornea to a point above the same; its width over the muscle is about one full centimetre at its greatest diameter. The conjunctiva is then separated around this elliptical wound from its subconjunctival tissues at all points, even around the cornea if possible.

3. The elliptical opening is brought together with four sutures; the upper suture is inserted through the conjunctiva and Tenon's capsule and across under the conjunctiva and Tenon's capsule, midway between the insertion of the superior rectus muscle and the margin of the cornea; a similar suture is passed through the lower margin of the conjunctiva and brought out midway between the insertion of the inferior muscle and the margin of the cornea; this thread is then tied, and in like manner the upper thread; two more sutures are passed through the margin of the lips of the wound and united.

This constitutes the details of the operation. The object of the operator should be to produce 1 to 4 millimetres of convergence, which disappears during cicatrization. When the defect is not more than 2 or 3 millimetres I have performed an external tenotomy on both and stretched Tenon's capsule, with excellent results, without taking out the elliptical section, especially in those cases where the eyes could be held by the patient at fixed convergence at 10 inches.

APPENDIX

GENERAL OPERATIVE TECHNIQUE

The operating-room used by ophthalmic surgeons differs in several particulars from that in use by general surgeons. Owing to the small field of operation, the light should be admitted from two sides, or from the top and one side of the room, and curtains or shades should be arranged so as to exclude any excessive light on very bright days, and also to lessen the corneal reflex and to make the room absolutely dark if necessary. The room should be provided with artificial illumination, preferably electric lights, for use in emergency work at night. At least one light should be movable, so as to permit its use with a condensing lens for detail examination of the eye. Means should be provided for ventilation without the production of draughts. All the chairs, tables, and other operating-room furniture should be made of metal and glass, which materials are most easily cleansed. The walls and floor of the operating-room should be marble for the same reason.

Operating tables have been devised from time to time, each of which has its special advantage. Many surgeons prefer a low bed or couch for the performance of cataract operations, restricting the high table for use in the remaining operative procedure. Personally, I use the high table, presently to be described, for all operations in the hospital. This table consists of a brass frame mounted upon four legs, the lower top of which is provided with casters (which may be locked if necessary) to facilitate moving it from place to place. Suitable braces are placed at each angle to render the framework firm and durable. The brass frame is made of rather thin tubing of highly polished brass, giving the entire table a neat appearance, a feature that is greatly ignored in most tables. The height of the table is 4½ feet, the width 1½ feet, and the length 6 feet. The top of the frame is covered by one piece of thick plate-glass, on the left side of which, near the head of the table, a semicircle is cut out to enable the surgeon to stand more directly in front of the patient's face. A corresponding curve is made in the framework in this location. A head-rest of metal and glass is provided, which permits of being raised or lowered to suit the convenience of the operator. The upper rim of the head-rest is tongued on its under surface for receiving the extremities of the head-clamps. The clamps, A, A, are two long, thin, flat pieces of metal, one end of which is heavy and thick, and grooved so as to fit snugly over the tongue of the rim of the head-rest. In using the clamps, they are made to slide along the rim of the head-rest until close up to the patient's head, any movement of which will cause them to bend upon the rim and become more firmly fixed. A detachable leaflet for holding an instrument tray and dressings is also provided for one side of the table.

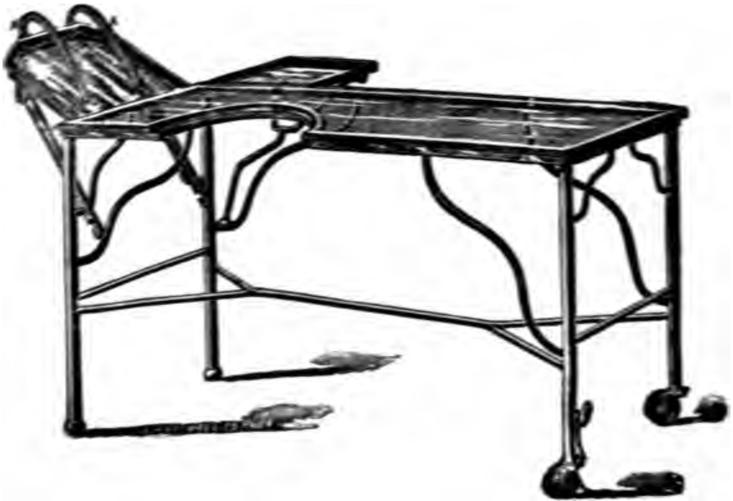

FIG. 235.—AUTHOR'S OPERATING TABLE.

INSTRUMENTS

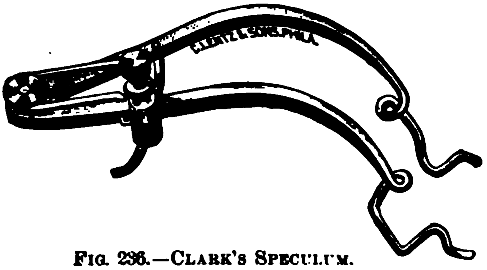

Fig. 236.—Clark's Speculum.

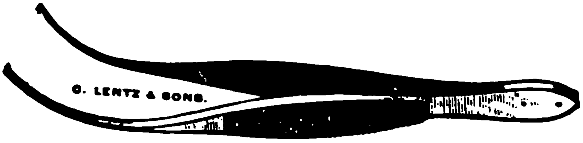

Fig. 237.—Curved Iris Forceps.

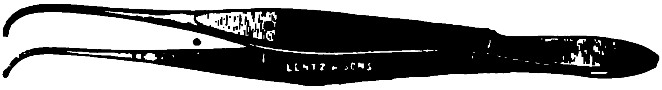

Fig. 238.—Full-curved Iris Forceps.

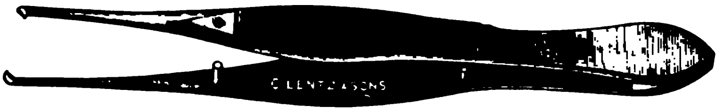

Fig. 239.—Straight Fixation Forceps.

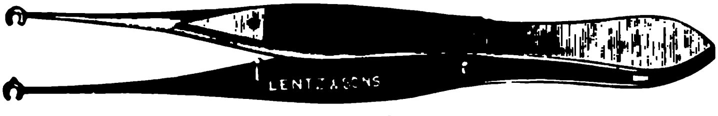

Fig. 240.—Fixation and Ligature Forceps.

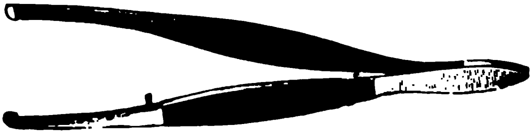

Fig. 241.—Cilia Forceps.

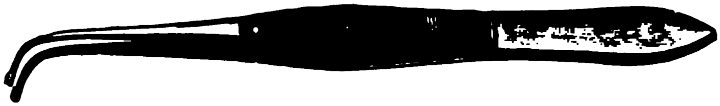

Fig. 242.—Couper's Capsular Forceps.

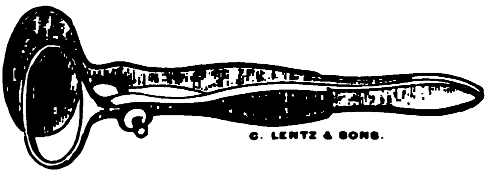

Fig. 243.—Desmarre's Entropion Forceps.

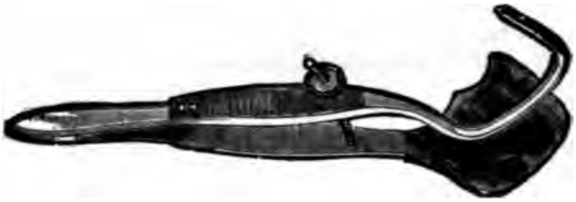

Fig. 244.—Snellen's Entropion Forceps.

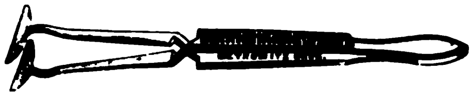

Fig. 245.—Author's Traction Forceps.

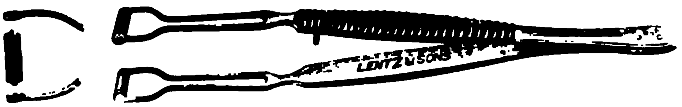

Fig. 246.—Knapp's Roller Forceps for Trachoma.

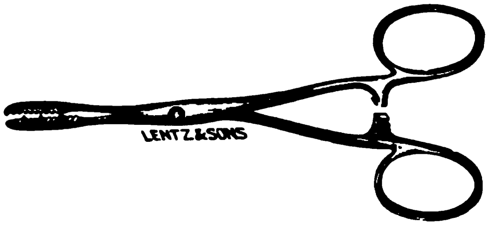

Fig. 247.—Darier's Grattage Forceps.

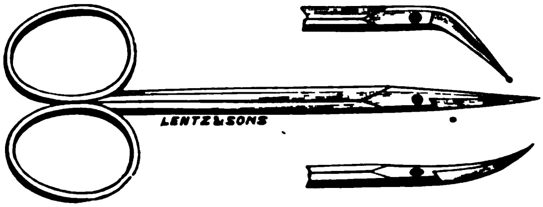

Fig. 248.—Iris Scissors.

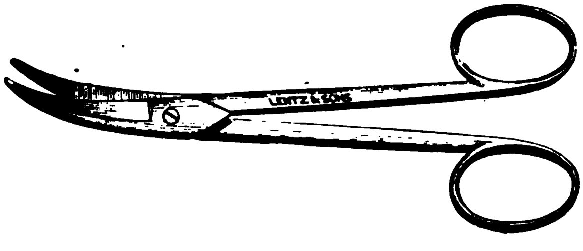

Fig. 249.—Curved Enucleation Scissors.

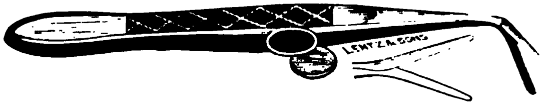

Fig. 250.—De Wecker's Iris Scissors.

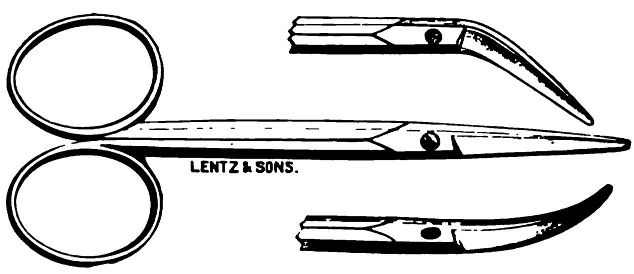

Fig. 251.—Strabismus Scissors

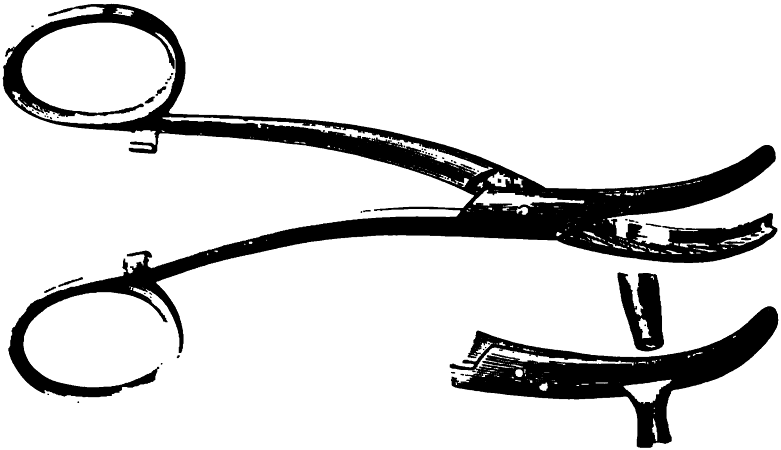

FIG. [illegible] SCISSORS [illegible] RESECTION OF OPTIC NERVE.

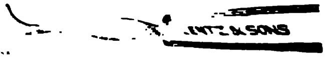

FIG. [illegible] KERATOME.

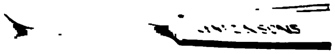

FIG. [illegible] KERATOME.

FIG. [illegible] THE OPERATION [illegible]

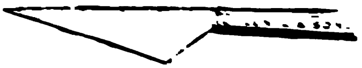

FIG. [illegible] CATARACT KNIFE.

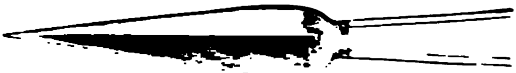

FIG. [illegible] CATARACT KNIFE.

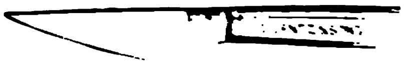

FIG. [illegible].—[illegible] CATARACT KNIFE.

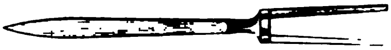

Fig. 259.—Critchett's Modified Graefe Knife.

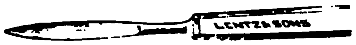

Fig. 260.—Scalpel.

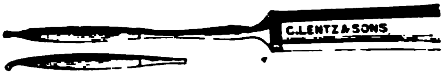

Fig. 261.—Bowman's Probe-point Knife.

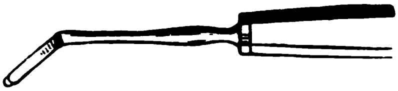

Fig. 262.—Desmarre's Angular Secondary Knife

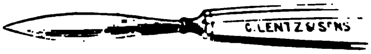

Fig. 263.—Extra Broad Paracentesis Needle.

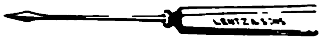

Fig. 264.—Beer's Straight Cataract Needle.

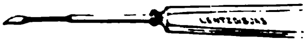

Fig. 265.—Bowman's Cataract Needle with Stop.

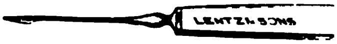

Fig. 266.—Hayes's Knife Needle.

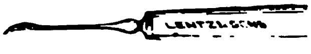

Fig. 267.—Knapp's Curved Knife Needle.

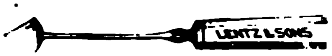

Fig. 268.—Desmarre's Broad Paracentesis Needle

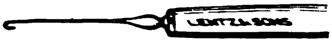

FIG. 269.—TYRRELL'S BLUNT HOOK.

FIG. 270.—TYRRELL'S SHARP HOOK.

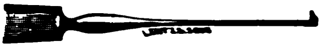

FIG. 271.—CYSTOTOME.

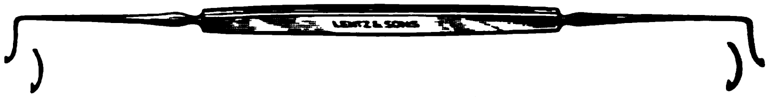

FIG. 272.—JAEGER'S ANGULAR CYSTOTOME.

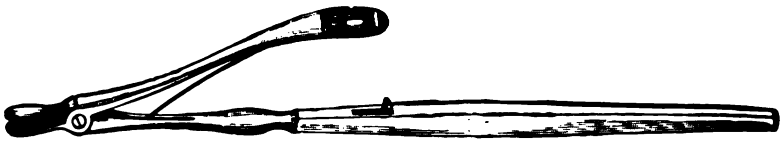

FIG. 273.—KNAPP'S IMPROVED ASEPTIC NEEDLE HOLDER.

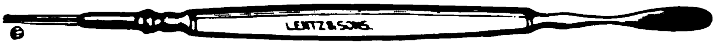

FIG. 274.—TATTOOING NEEDLE WITH SILVER SPATULA.

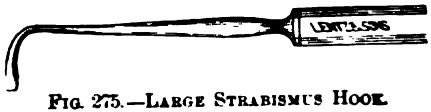

FIG. 275.—LARGE STRABISMUS HOOK.

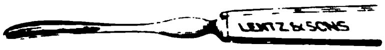

FIG. 276.—DAVIEL'S LENS SCOOP.

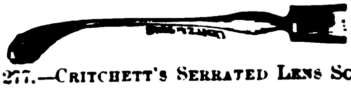

FIG. 277.—CRITCHETT'S SERRATED LENS SCOOP.

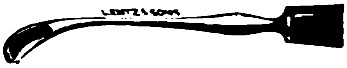

FIG. 278.—CRITCHETT'S CONCAVE LENS SCOOP.

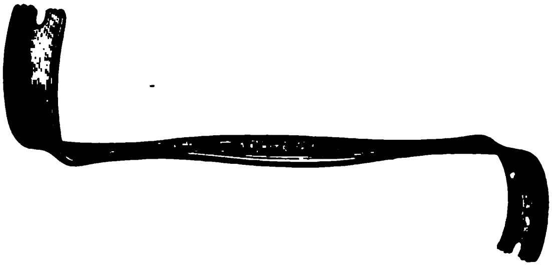

Fig. 279.—Author's Retractor for Resection of the Optic Nerve.

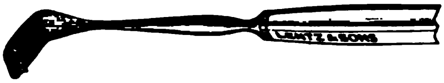

Fig. 280.—Carter's Retractor for Resection of the Optic Nerve.

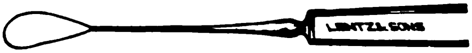

Fig. 281.—Levis's Pliable Steel Loop.

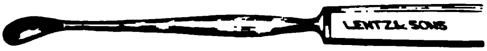

Fig. 282.—Graefe's Tortoise-shell Lens Scoop.

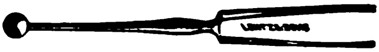

Fig. 283.—Meyhoefer's Round Scoop with Sharp Edges.

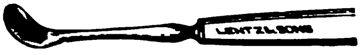

Fig. 284.—Lid Scarifying Knife.

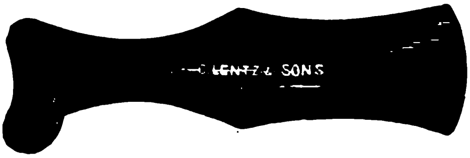

Fig. 285.—Author's Tortoise-shell Lid Retractor

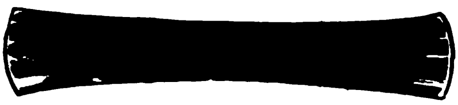

Fig. 286.—Jaeger's Lid Spatula.

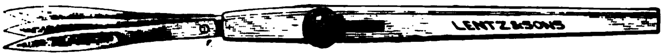

FIG. 287.—DARIER'S GRATTAGE SCARIFIER.

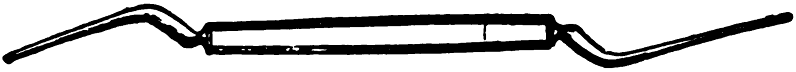

FIG. 288.—LEVI'S LACRYMAL DILATOR.

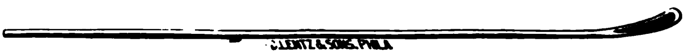

FIG. 289.—MEIBOMIAN SCOOP.

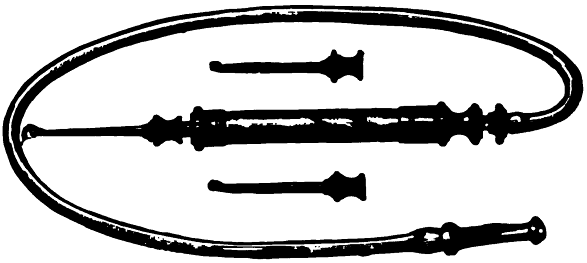

FIG. 290.—TEALE'S SUCTION CURETTE FOR SOFT CATARACT.

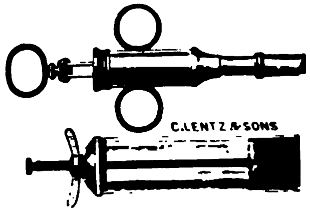

FIG. 291.—LUER'S ARTIFICIAL LEECH.

The dressings in use by ophthalmic surgeons should be thoroughly sterilized in the ordinary dry sterilizer or one of its modifications. Aseptic are far more preferable than antiseptic dressings, on account of the reactive inflammations of the eyelids and conjunctiva that may follow the continued contact with powerful antiseptics. It must be remembered, however, that owing to the open condition of the conjunctival *cul-de-sac* the eye is more tolerant than would be supposed at first sight. Patent lint and absorbent cotton held in place by a gauze bandage constitute the dressing for ordinary conditions.

In cases in which the bandage is undesirable, the dressing may be held in place by a hexagon-shaped, knitted, black pad, to each end of which is attached a piece of black tape. Adhesive plaster may occasionally be substituted for the tape. This pad is less conspicuous and more comfortable than the ordinary single Liebreich bandage. When it is necessary to keep the lids closed, as after cataract operations, iridectomies, etc., sterilized petrolatum should be smeared abundantly over the closed lids. A small pad, as shown in the illustration (Fig. 293), made of two layers of gauze inclosing a layer of absorbent cotton, should then be placed over the eye with the curved border corresponding to the supraorbital arch. A large rectangular pad (Fig. 292) similarly made, but with the addition of a sheet of black linen, is then placed over both eyes. This pad is 6 inches long and 3½ inches wide, and partially divided in the centre in order to fit over the nose. Strips of adhesive plaster are used to fasten the dressing above and below. A perforated aluminium

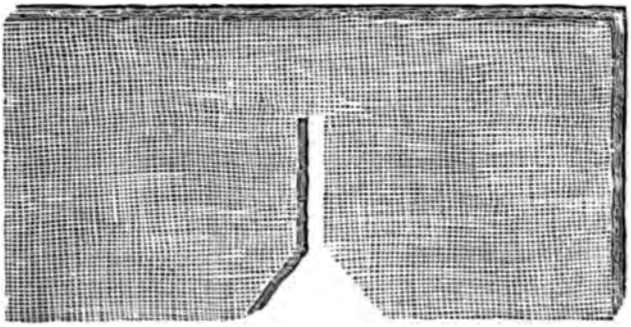

FIG. 292.—DOUBLE EYE PAD.

shield (Fig. 294), moulded to fit the face, should then be placed over the eye operated upon and held in place by adhesive strips.

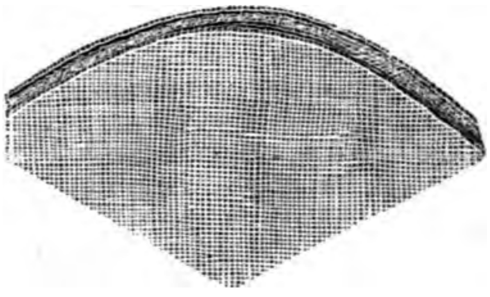

FIG. 293.—SINGLE EYE PAD.

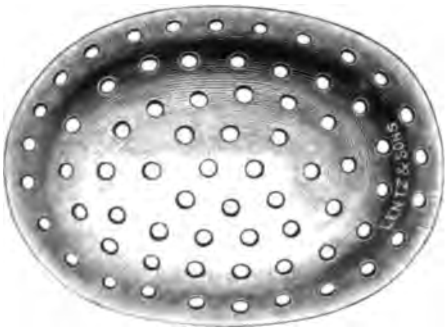

FIG. 294.—PERFORATED ALUMINIUM SHIELD.

Preparatory Treatment.—Before proceeding to any operation upon the eye, not only the condition of the ocular structures should be examined, but the general condition should be considered in detail. The chapter upon the Relationship between Ocular Affections and General Diseases serves to emphasize the importance of such a procedure. The urine should always be examined carefully to determine the functional activity and general condition of the kidneys. The heart and lungs should likewise be examined, as the presence of a very slight bronchitis may contra-indicate any operation in which the eye is opened, on account of the increased intra-ocular tension that accompanies coughing. During convalescence from influenza and typhoid fever the respective bacilli of these diseases often become pyogenic in character, and may cause the failure of an operation by inducing infection through the blood. This is also true of the more serious affections, such as pyæmia and septicæmia, but this possibility is more likely to be overlooked in the less grave infectious fevers. The presence of any pulmonary or cardiac condition would also contra-indicate general anæsthesia for ophthalmic operations except in occasional emergencies. The presence of rheumatism or syphilis should be carefully sought for, but this is often impossible for various reasons. Usually it is best to avoid undue questioning in such cases, and to administer strontium salicylate (grain v) and mercury with chalk (grain j) three times daily, for several days previous to the operation. The patient should restrict his diet to vegetables for a few weeks prior to the operation, particularly if it is to be a cataract extraction. (Baron Wenzel called attention to this important point in the preparation of patients for cataract extraction in the latter part of the eighteenth century.) The free use of water, especially some saline mineral water, is recommended on account of its diuretic and laxative effect. A moderate degree of exercise, with abundance of rest and sleep, is also advised. For twenty-four hours previous to any major ophthalmic operation the patient should remain in bed and partake of a very light diet. A tepid bath should be given and a saline laxative should be administered.

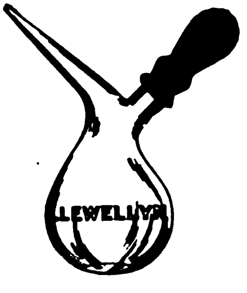

FIG. 295.—DROP BOTTLE.

Preparation of the Field of Operation.—The patient's face should be thoroughly cleansed with Castile soap and hot water on the morning of the operation, being careful not to irritate the eye by the entrance of soapsuds into the conjunctival *cul-de-sac*. The eye should then be thoroughly irrigated by a sterile boracic solution, after which, pads saturated with a 1-to-2,000 corrosive-sublimate solution should be applied and worn until ready for operation. Upon removing the pads the eyes are again irrigated and a drop of 1-to-2,000 corrosive-sublimate solution is instilled. If the operation is to be performed under local anæsthesia, two or three drops of cocaine (5-per-cent solution) should be instilled every three minutes for five or ten minutes. Using this drug for a longer period induces haziness of the cornea and interferes with its nutrition. Atropine (grain j to drams iij) should be instilled in ordinary operations upon the cornea, lens, and iris, but not in glaucomatous cases or simple cataract operations, two hours before the time set for the operation. At the completion of the operation, if there is reason to suspect any iritic complications, atropine should be again instilled. The eye should be irrigated with the boracic-acid solution, and a few drops of sublimate solution should be instilled. The dressings already supplied should then be applied with great care and extreme gentleness. Subsequent dressings should be made daily or at greater intervals, depending upon the character of the operation. The room in which the patient is to be confined should be as dark as is compatible with safety. If the patient is to remain in bed the room should be almost completely dark, but if he is allowed to move about sufficient diffused light should be allowed to prevent stumbling over the furniture of the room, of which there should be as little as possible. After cataract operations the patient should be carefully watched, to prevent tearing off the dressings, which are sometimes a great annoyance to the patient, particularly in warm weather. The dressings may be removed at the end of the first week.

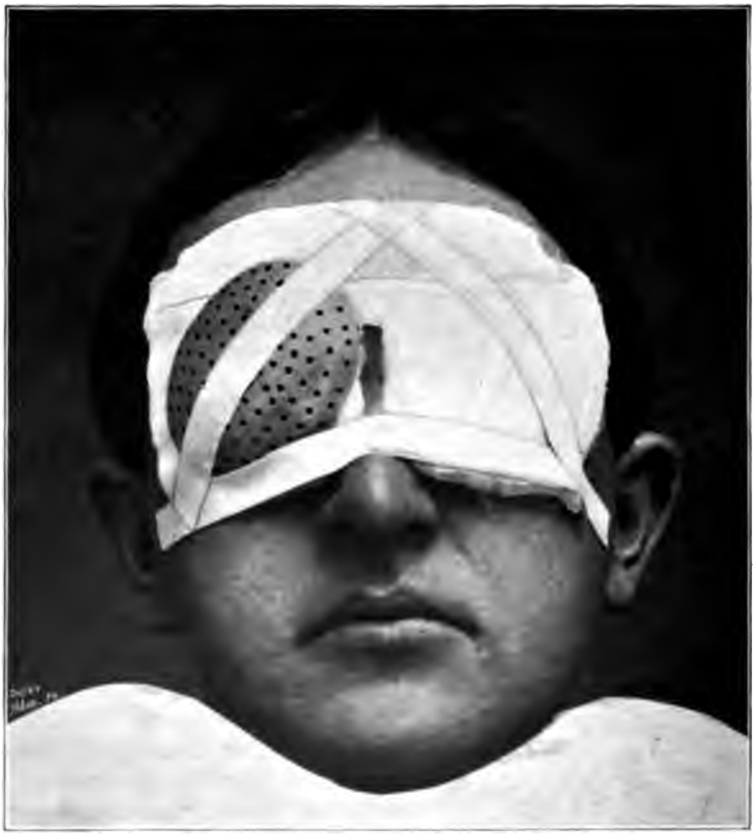

FIG. 296.—DOUBLE EYE PAD (FIG. 292) WITH SHIELD (FIG. 294) AS ADJUSTED IN CATARACT OPERATION OR IRIDECTOMY.

FORMULARY

AFFECTIONS OF THE LIDS

1. ℞ Liquor plumbi subacetatis dil... 7.39 cc. or ʒ ij;
Tincturæ opii }
Tincturæ belladonnæ } ......āā 5.53 cc. or ʒ jss.;
Tincturæ arnicæ............... 30.00 cc. or ℥ j;
Aquæ camphoræ }
Aquæ destillatæ } ...āā q. s. ad. 120.00 cc. or ℥ iv.
M. Sig.: Poison. Use for œdema of the lids.

2. ℞ Ichthyol.......... ..... 0.50 gm. or gr. viij;
Zinc. oxid............. 2.00 gm. or gr. xxxj;
Amidon............... 2.00 gm. or gr. xxxj;
Vaseline.............. 10.00 gm. or gr. clv.
M. Sig.: (Darier.) Apply locally at night. (For Blepharitis.)

3. ℞ Hydrarg. oxidi flav. .065 gm. to .518 gm. or gr. j to gr. viij;
Petrolat }
Ol. rosæ q. s. } 30.00 gm. or ℥ j
M. Sig.: Apply locally once daily. (Blepharitis.)

4. ℞ Resorcin.................... .03 gm. or gr. ss.;
Petrolat.................... 3.88 gm. or ʒ j;
M. Sig.: Apply locally. Excoriations of lids.

5. ℞ Sol. boroglyceride (25%)....... .610 cc. or ♏ x;
Ung. aq. rosæ................ 3.88 gm. or ʒ j.
M. Sig.: Apply locally. (Blepharitis.)

CONJUNCTIVITIS

6. ℞ Sodii chloridi........... .972 gm. or gr. xv;
Acidi borici............. 1.296 gm. or gr. xx;
Aquæ camphoræ }
Aquæ destillatæ } .....āā 60.000 cc. or āā ℥ ij.
M. Sig.: Bathe the eye 3 times daily.

This (No. 6) is the simplest form of an eye lotion, and may be used in all corneal and conjunctival inflammations.

7. ℞ Hydrargyri bichloridi...... .0009 gm. or gr. $\frac{1}{76}$;
Sodii chloridi.............. .972 gm. or gr. xv;
Acidi borici............... 1.296 gm. or gr. xx;
Aquæ camphoræ }
Aquæ destillatæ } .... āā 45.000 cc. or āā ℥ jss.
M. Sig.: Bathe eyes freely.

Useful in catarrhal conjunctivitis with muco-purulent discharges.

8. ℞ Acidi borici }
Sodii biboratis } ....:āā 1.94 gm. or ʒ ss.;
Aquæ menthæ pip......... 11.09 cc. or ʒ iij;
Ext. hamamelis dest....... 15.00 cc. or ʒ iv;
Aquæ camphoræ }
Aquæ destillatæ } ......āā 60.00 cc. or āā ℥ ij.
M. Sig.: Bathe eyes freely.

A much-used formula in catarrhal conjunctivitis with corneal complications.

9. ℞ Zinc. sulphat..... .065 to .130 gm. or gr. j to gr. ij;
Aquæ destillatæ.. 30.00 cc. or ℥ j;
M. Sig.: Drop in affected eye 3 times daily.

For simple catarrhal conjunctivitis.

10. ℞ Acid. boric................ .648 gm. or gr. x;
Cocain. hydrochlor......... .0324 gm. or gr. ss.;
Aquæ.................... 30.0000 cc. or ℥ j.
M. Sig.: Drop in each eye 3 times daily.

For simple catarrhal conjunctivitis.

11. *Finely powdered*
Calomel,
Iodoform,
Airol,
Protargol,
Xeroform,

May be insufflated with satisfactory results over corneal, conjunctival, or cutaneous wounds.

12. ℞ Argenti nitratis.......... .648 gm. or gr. x;
Aquæ destillatæ.......... 30.00 cc. or ℥ j.
Sig.: One or two drops instilled into both eyes as soon after the birth of a child as possible (Credé). Prophylaxis in ophthalmia neonatorum.

13. ℞ Protargol (20-per-cent solution).
Sig.: Instil several drops into the eye every two hours.

Most efficacious in purulent discharges from the eyes. A silver albumose containing eight per cent of metallic silver. It is free from all caustic or corrosive effects. Neisser lays particular stress on its non-irritant properties, which make it preferable to other silver salts for prolonged use. It also appears to penetrate deeper into the cellular tissue.

14. ℞ Argentamine (containing 6.35 per cent of silver), 5-per-cent solution.

15. ℞ Argonine (containing 4 per cent of silver), 1- to 2-per-cent solution.

16. ℞ Itrol (silver citrate), 1- to 3-per-cent solution.

17. ℞ Ichthargan (a combination of ichthyol and silver) 3-per-cent solution.

18. ℞ Argyrol—20- to 50-per-cent solution.

19. ℞ Adrenalin chlorid. In solution from 1 : 10,000 to 1 : 1,000.

20. ℞ Cocain. hydrochlor............ 0.10 gm. or gr. jss.;
Adrenalin (1 : 1,000)........... 1.00 gm. or gr. xvss.;
Sol. mercuric cyanid (1 to 2,000). 10.00 cc. or ʒ ij⅓.
M. Sig.: One drop in the affected eye as required. (Recommended by Darier in conjunctivitis, iritis, and episcleritis.)

21. ℞ Cuprol.................... 5.82 gm. or ʒ jss.;
Aquæ destillatæ........... 30.00 cc. or ℥ j.
M. Sig.: To be used as a substitute for the copper pencil in granular conjunctivitis.

PURULENT CONJUNCTIVITIS

22. ℞	Zinci chloridi	.259 gm. or gr. iv;
	Acidi borici	.775 gm. or gr. xij;
	Tr. belladonnæ Vini opii	āā 7.39 cc. or āā ʒ ij;
	Aquæ camphoræ Aquæ destillatæ	āā 60.00 cc. or āā ℥ ij.

M. Sig.: Use locally twice daily.

For ophthalmia neonatorum with marked œdema of the eyelids. Applied with iced cotton pledgets.

23. ℞[1]	Hydrastine hydrochlorate	.259 gm. to .389 gm. or gr. iv–vj;
	Acidi borici	1.296 gm. to gr. xx;
	Tr. opii deod	7.390 cc. or ʒ ij;
	Aquæ destillatæ	120.000 cc. or ℥ iv.

M. Sig.: Eye lotion.

Used in ophthalmia neonatorum and in all forms of catarrhal conjunctivitis.

24. ℞	Hydrargyri bichloridi corrosivi	.0022 gm. or gr. $\frac{1}{30}$;
	Eserinæ sulph	.130 gm. or gr. ij;
	Vini opii	7.390 cc. or ʒ ij;
	Aquæ camphoræ Aquæ destillatæ	āā 60.000 cc. or āā ℥ ij.

M. Sig.: Eye lotion. Poison. Purulent conjunctivitis.

25. ℞	Eserinæ sulph	.130 gm. or gr. ij;
	Quininæ hydrochlor	.648 gm. or gr. x;
	Aquæ camphoræ Aquæ destillatæ	āā 60.000 cc. or āā ℥ ij.

M. Sig.: Used where there is a membranous deposit.

26. ℞ Sol. Hydrargyri bichloridi (1 to 2,000).
Sig.: Poison. Apply iced cold.

27. ℞	Eserinæ sulph	.0162 gm. or gr. $\frac{1}{4}$;
	Hydrargyri oxidi flavi	.0081 gm. to .065 gm. or gr. $\frac{1}{8}$–j;
	Petrolat	3.8800 gm. or ʒ j.

M. Sig.: Ulcerations of the cornea following purulent conjunctivitis.

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[1] Salt of the white alkaloid of golden seal.

28. ℞ Daturinæ sulphatis........ .0108 gm. or gr. $\frac{1}{6}$;
Hydrargyri oxidi flavi...... .0081 gm. or gr. $\frac{1}{8}$;
Petrolat.................... 3.8800 gm. or ʒ j.
M. Sig.: Used in ulcerations following conjunctivitis.

29. ℞ Cupri sulphatis. .... .061 gm. or gr. j;
Acidi salicylici .... .130 gm. or gr. ij;
Cocaine hydrochloratis..... .194 gm. or gr. iij;
Petrolatum................ 31.000 gm. or ℥ j.
M. Sig.: Use locally in granular lids.

30. ℞ Unguenti boroglyceridi (25 per cent).
Use locally in trachoma.

31. ℞ Hydrargyri oxidi flavi, Ichthyol ammon. } .....āā .008 gm. or āā gr. $\frac{1}{8}$;
Petrolat..................... 3.88 gm. or ʒ j.
M. Sig.: Use locally in ulcers of the cornea.

32. ℞ Cerevisine (25-per-cent solution).
Sig.: Instil into eye 4 times daily. Gonorrhœal ophthalmia.

33. ℞ Iodoform............... 1.296 gm. or gr. xv;
Atropin. sulphatis....... .130 gm. or gr. ij;
Petrolat............. .. 31.000 gm. or ℥ j.
M. Sig.: Apply locally twice daily. For corneal ulcerations.

34. ℞ Hydrarg. oxidi flavi....... .130 gm. or gr. ij;
Atropin. sulphatis...... ... .130 gm. or gr. ij;
Petrolat............... . 31.000 gm. or ℥ j.
M. Sig.: Apply locally, once daily. For corneal ulcerations.

FOR PHLYCTENULAR KERATITIS

35. ℞ Dionin........................ 0.10 gm. or gr. jss.;
Cocain. hydrochlorat............ 0.10 gm. or gr. jss.;
Sol. mercuric cyanid. (1 : 2,000). 10.00 cc. or ʒ ijss.
M. Sig.: One drop in the affected eye every hour. (Darier.)

FOR KERATITIS IN WHICH THERE IS MUCH VASCULARITY OF THE CORNEA, YELLOW OXIDE OF MERCURY OINTMENT COMBINED WITH THE USE OF THE FOLLOWING IS OF VALUE:

36. ℞ Cocain. hydrochlorat............ 0.10 gm. or gr. jss.;
Adrenalin (1 : 1,000) solution.... 2.00 cc. or ʒ ss.;
Sol. mercuric cyanid (1 : 1,500)... 8.00 cc. or ʒ ij.
M. Sig.: One drop locally every two hours. (Darier.)

FOR IRITIS

37. ℞ Dionin .... 0.10 gm. or gr. jss.;
Cocain. hydrochlor....... 0.10 gm. or gr. jss.;
Atrop. sulphat.......... 0.05 gm. or gr. ¾;
Aq. destillat.............. 10.00 cc. or ʒ ijss.
M. Sig.: One drop in affected eye 8 times daily. (Darier.)

FOR GLAUCOMA

38. ℞ Pilocarpin hydrochlor.. 0.5 gm. to 0.10 or gr. jss. to vijss.;
Eserin. sulphat........ 0.2 gm. or gr. iij;
Sol. adrenalin (1 : 1,000) 2.5 cc. or gr. xxxviij;
Aq. destillatæ........ad. 10.00 cc. or ʒ ijss.
M. Sig.: Use locally 5 or 6 times daily. (Darier.)

FOR INTERNAL ADMINISTRATION IN SYPHILITIC AFFECTIONS

39. ℞ Hydrarg. biniodid........ .065 gm. or gr. j;
Potass. iodid.............. 7.77 gm. or ʒ ij;
Essence of pepsin.......... 90.00 cc. or ℥ iij.
M. Sig.: Teaspoonful in water after meals.

MYDRIATICS AND CYCLOPLEGICS

40. ℞ Atropin. sulphat.......... .065 gm. or gr. j;
Aquæ destillatæ........... 7.390 cc. or ʒ ij.
M. Sig.: Poison. One drop in each eye 3 times daily.

41. ℞ Cocain. hydrochlorat. .648 gm. to 1.296 gm. or gr. x–xx;
Aquæ destillatæ.... 30.000 cc. or ℥ j.
M. Sig.: Two drops every minute for local anæsthesia.

42. ℞ Duboisin. sulphat........ .0324 gm. or gr. ss.;
Aquæ destillatæ.......... 7.3900 cc. or ʒ ij.
M. Sig.: One drop 3 times daily.

43. ℞ Homatropin. hydrobromate .648 to .972 gm. or gr. x to xv;
Aquæ.................... 30.000 cc. or ℥ j.
M. Sig.: One drop every 10 minutes for 1 hour (refraction).

44. ℞ Scopalamin.............. .0081 gm. or gr. ⅛;
Aquæ destillatæ.......... 7.3900 cc. ʒ ij.
M. Sig.: One drop every fifteen minutes for one hour.

45. ℞ Hyoscyamin. hydrobromat.... .0324 gm. or gr. ss.;
Aquæ destillatæ .... 7.39 cc. or ʒ ij.
M. Sig.: One drop 3 times daily.

46. ℞ Euphthalmin. hydrochlor.. .194 gm. or gr. iij;
Aquæ destillatæ........... 3.70 cc. or ʒ j.
M. Sig.: One drop as required. (For mydriasis without cycloplegia).

MYOTICS

47. ℞ Pilocarpin hydrochlorat. .0162 gm. to .0324 gm. or gr. ¼
Aquæ destillatæ....... 7.3900 cc. or ʒ ij. [to ½;
M. Sig.: One drop 3 times daily.

48. ℞ Eserin. sulphat.. .00405 gm. to .0324 gm. or gr. $\frac{1}{16}$ to ½;
Aquæ destillatæ. 7.39000 cc. or ʒ ij.
M. Sig.: One drop 3 times daily.

FOR DETERMINING DENUDED AREAS OF CORNEA

49. ℞ Fluorescin............... .259 gm. or gr. iv;
Liq. potassa............ 3.700 cc. or ʒ j;
Aquæ destillatæ.......... 15.000 cc. or ʒ iv.
M. Sig.: Instil one drop and then irrigate the eye; the denuded areas will appear yellowish green.

OCULAR ANÆSTHETICS

50. ℞ Cocain.................. 3- to 5-per-cent solution.

51. ℞ Holococain............. 1-per-cent solution.

52. ℞ Acoin .... 1-per-cent solution.

53. ℞ Dionin............... ... 5-per-cent solution.

54. ℞ Xeroform............... 4 gm. or ʒ j;
Vaselin................. 31 gm. or ℥ j.
M. Sig.: Ung. For painful ulcers and burns of eye. (Darier.)

55. ℞ Sol. chinosol (1 : 2,000).
Sig.: Instil freely into eye every three hours. (For vernal conjunctivitis.)

GLOSSARY

A

Abatio retinæ.—Detachment of the retina.

Aberration.—Imperfect refraction or focalization of a lens.

Achromatopsia.—Inability to distinguish colours.

Acne.—An inflammation of the sebaceous glands.

Acritochromacy.—Colour-blindness.

Ægilops.—A name given by older surgeons to an ulcerating sinus at the inner angle of the eyelids.

Albugo.—Any clouding of the cornea.

Amaurosis.—Partial or total loss of vision from paralysis of the optic-nerve apparatus.

Amblyopia.—Impaired vision from defective sensibility of the retina.

Ametropia.—The formation of an imperfect image on the retina, due to imperfect refractive power of the media.

Amianthinopsy.—Violet-blindness.

Amphiblestroiditis.—Inflammation of the retina.

Amyloid.—Formation of a substance in many respects similar to starch.

Anæmia.—Deficiency of blood or one or more of its constituents.

Anaphoria.—Diminished depression of both corneas.

Anchilops.—Name given by older surgeons to an abscess at the inner angle of the palpebral aperture.

Anchyloblepharon.—Adhesion of the ciliary edges of the eyelids.

Angeioma.—Tumour mass composed of blood-vessels.

Aniridia.—Absence or defect of the iris.

Anisokoria.—Inequality in the diameters of the pupils.

Anisometropia.—A condition characterized by a difference in the refraction in the two eyes.

Anophthalmus.—A congenital absence of the eyes.

Anopsia.—Upward strabismus.

Aphakia.—An absence of the crystalline lens.

Arcus senilis.—Circular corneal opacity in aged persons.

Asthenopia.—Weak-sightedness or speedy fatigue of visual power.

Astigmatism.—Defect in which light rays are not brought to a proper focus by the unaided eye.

Atresia.—Closure or imperforate condition of the pupil.

Atrophy.—A condition marked by wasting or malnutrition.

B

Binocular.—Pertaining to both eyes.

Blennorrhœa.—An overabundant or excessive discharge of mucous or serous material.

Blepharadenitis.—Inflammatory condition of the Meibomian glands.

Blepharitis.—Inflammation of the eyelids.

Blepharoblennorrhœa.—First stage of puromucous inflammation of the conjunctiva.

Blepharophimosis.—A contracted condition or smallness of the palpebral fissure.

Blepharophthalmia.—Puromucous inflammation of the conjunctiva in its fully formed state.

Blepharoplasty.—A plastic operation upon the eyelids.

Blepharoplegia.—Paralysis of one or more of the eyelids.

Blepharoptosis (also called ptosis).—A dropping down of the upper eyelid.

Blepharospasmus.—Spasm of the eyelids.

Bullosa.—Bleb formation.

Buphthalmos.—Enlargement of the eyeball, the result of a dropsy or a tumour; resembling the eye of an ox.

C

Canaliculus.—A small canal or groove.

Cancroid.—Like cancer.

Canthoplasty.—A plastic operation upon the eyelids for the restoration of either canthus.

Canthus.—Angle of the eye.

Capsulotomy.—Incision of the capsule of the crystalline lens.

Caruncle.—A fleshy protuberance at the inner canthus.

Cataract.—An opacity of the lens, its capsule, or both.

Catarrh.—Inflammation of a mucous membrane.

Ceratitis.—Inflammation of the cornea.

Ceratocele.—Hernia of the cornea.

Ceratome.—A knife used for making an incision into the cornea.

Chalazion.—A Meibomian cyst, the result of closure of the duct leading from the gland.

Chemosis.—Swelling of the conjunctiva, as result of exudation into the sub conjunctival cellular tissue.

Chorioiditis.—Inflammatory condition of the chorioid.

Chromatopsy.—Coloured vision.

Chromidrosis.—Coloured sweat.

Cilia.—Eyelashes.

Collyrium.—An eye lotion or salve.

Coloboma.—Fissure of parts of the eye, either congenital or traumatic in origin.

Coma.—An abnormally prolonged sleep.

Conus.—Crescentic patch of chorioidal atrophy near disk, seen in myopia.

Copiopia.—A fatigued condition of the eyes.

Corectomia.—Operation for artificial pupil by excision.

Corectopia.—Displacement of the pupil.

Coredialysis.—Operation for artificial pupil by separation.

Corelysis.—Detachment of adhesion between the iris and the lens.

Coremorphosis.—Operation for artificial pupil in general.

Coreometry.—Measurement of the pupil.

Coreoncion.—Hook invented for the operation for artificial pupil by separation.

Coreplastice.—Operation for artificial pupil in general.

Cornea.—The anterior transparent segment of an eyeball.

Corneitis.—Inflammation of the cornea.

Corotomia.—Operation for artificial pupil by incision.

Couching.—An old operation for cataract in which the lens is depressed into the vitreous.

Cryptophthalmos.—Congenital union of the eyelids together with imperfectly formed eyes.

Cyclitis.—Inflammation of the ciliary body.

Cyclophoria.—Insufficiency of the oblique muscles.

Cycloplegia.—Paralysis of the ciliary muscle.

D

Dacryoadenitis.—Inflammation of the lacrymal gland.

Dacryocystitis.—Inflammation of the lacrymal sac.

Dacryocystoblennorrhœa.—Flow of tears or mucus from the lacrymal sac, as result of irritation.

Dacryohæmorrhysis.—Sanguineous lacrymation.

Dacryolith.—Calculous concretions deposited in the passages leading from the gland.

Dacryoma.—Stillicidium lachrymarum.

Dacryops.—" Watering eyes."

Daltonism.—Colour-blindness.

Dendritica.—Tree-like.

Descemititis.—Inflammation of Descemet's membrane, the posterior layer of the cornea.

Dialysis.—Passing of any substance through a membrane.

Diopter.—The metric unit of measurement for optical lenses.

Diplopia.—Double vision.

Discission.—A tearing operation performed for soft cataract.

Distichiasis.—A form of trichiasis in which the maldirected eyelashes form a second row distinct from the others.

E

Ectasia.—Abnormal dilatation or distention of a part.

Ectropium.—Eversion of the eyelids.

Eczema.—An acute, subacute, or chronic inflammatory disease of the skin of the eyelids, characterized by the formation of papules, vesicles, pustules, etc.

Emmetropia.—Normal or perfect vision.

Encanthus.—Enlargement of the lacrymal caruncle.

Enophthalmos.—Recession of the eyeball into the orbit.

Entropium.—Inversion of the eyelids.

Epicanthus.—A congenital peculiarity characterized by a fold of skin extending over the inner canthus.

Epilation.—Extraction of hairs.

Epiphora.—An excessive discharge and overflow of tears.

Erythropsia.—Red vision.

Esophoria.—Tending of the visual line inward.

Esotropia.—Inward deviation of the eyes.

Exophoria.—Tending of the visual line outward.

Exophthalmos.—Protrusion or an abnormal prominence of the eyeball.

Exotropia.—Outward deviation of the eyes.

F

Fovea Centralis.—The centre of the macula lutea, the point of most acute vision.

Furuncle.—A boil.

G

Gerontoxon.—Arcus senilis.

Glaucoma.—A disease of the eye characterized by a greenish opaque appearance behind the pupil.

Glioma.—A variety of round-celled sarcoma, affecting the retina and optic nerve.

Grando.—Chalazion.

Gutta opaca.—Name given by the Arabians to cataract, as they supposed it to be an opaque drop in front of the lens.

Gutta serena.—Name given by the Arabians to amaurosis, supposing it to depend on a clear drop fallen from the brain into the eye.

H

Hæmophthalmos.—Effusion of blood into the eye.

Hemeralopia.—Night-blindness; day vision.

Hemiopia.—A defective state of vision in which one half of the visual field is wanting.

Heterochromia.—A difference in colour in the irides.

Heterophoria.—A tending of the visual lines other than to parallelism.

Heterotropia.—A deviation of the eyes from their normal position.

Hippus.—Spasmodic movements of the pupils, independent of the action of light.

Hordeolum.—A stye.

Horopter.—A line representing the curve along which both eyes can join in sight.

Hyalitis.—Inflammation of the hyaloid membrane.

Hydrophthalmos.—Dropsy of the eye.

Hyperesophoria.—Tending of the visual line upward and inward.

Hyperexophoria.—Tending of the visual line upward and outward.

Hyperkeratosis.—A conical cornea.

Hypermetropia.—Far-sightedness.

Hyperopia.—Far-sightedness; focusing of parallel rays behind the retina.
Hyperphoria.—A tendency of a visual line upward.
Hyphæmia.—Deposition of blood on the floor in the anterior chamber of the eye.
Hypochyma.—A cataract.
Hypogala.—Effusion of a milky-like substance into the anterior chamber.
Hypophoria.—A tendency of a visual line downward.
Hypopyon.—Collection of pus in the anterior chamber.

I

Illaqueation.—An operation in which the direction of an eyelash is changed by means of a loop around its base.
Ireankistron.—An instrument invented for the purpose of performing an operation of artificial pupil by separation.
Iridauxesis.—Thickening of the iris due to exudation of some material into its tissues.
Iridectomy.—Cutting out a part of the iris.
Iridectomedialysis.—Operation for artificial pupil by a combination of excision and separation.
Iridectomia.—Operation for artificial pupil by excision.
Iridencleisis.—The strangulation of a prolapsed portion of the iris between the lips of an incision in the cornea in certain operations for artificial pupil.
Irideremia.—Absence of one or both irides.
Iridodialysis.—Release of iris at its ciliary border.
Iridodonesis.—Tremulousness of the iris.
Iridoperiphakitis.—Inflammation of the uvea and anterior wall of capsule of the lens.
Iridoplegia.—Paralysis of sphincter of the iris.
Iridoschisma.—A fissure of the iris.
Iridotomy.—Incision into the iris.
Iritis.—Inflammatory condition of the iris.
Ischæmia.—Bloodlessness.
Isocoria.—Equality in size of pupils.

K

Kataphoria.—Diminished elevation of both corneas.
Keratitis.—Inflammation of the cornea.
Keratocele.—A hernia of Descemet's membrane through the cornea.
Keratoconus.—Conical cornea.
Keratoglobus.—Protrusion of cornea.
Keratomalacia.—Softening of the corneal tissue.
Keratome.—An instrument for incising the cornea.
Keratonyxis.—Puncture of the cornea in needle operations for cataract.
Keratoscopy.—Examination of the cornea.
Kopiopia.—Weariness of the eyes due to overuse, etc.
Korectopia.—Displacement of the pupil.

L

Lacrymal.—Having reference to the apparatus for the tear secretion and conduction.

Lagophthalmus.—Inability to close the eyes perfectly.

Leukoma.—Opaque whitish spot of the cornea.

Lippitudo.—Falling out of lashes: marginal blepharitis.

Lithiasis.—Callosity within the tarsal plate.

Luscitas.—Fixed misdirection of the eye.

M

Macropsia.—Apparent increase in the size of objects viewed by the eye.

Madarosis.—Falling out of the eyelashes.

Malacia.—Softening of tissues.

Marmarygæ.—Appearance of sparks before the eyes.

Megalopsia.—An apparent increase in the size of objects.

Metamorphopsia.—Apparent change in the form of objects viewed by the eye.

Mication.—Rapid winking.

Microphthalmos.—A smaller eye than normal.

Micropsia.—Apparent decrease in the size of objects viewed by the eye.

Milium.—A small whitish tumour on the eyelids.

Miosis.—Decrease in the size of the pupil.

Monoblepsia.—State in which vision is distinct when only one eye is used.

Mucocele.—Dropsy of the lacrymal sac.

Muscæ volitantes.—Appearance of grayish motes before the eyes.

Mydriasis.—Abnormal dilatation of the pupil.

Myodesopsia.—Same as muscæ volitantes.

Myopia.—Near-sightedness.

Myosis.—Preternatural contraction of the pupil.

Myotomy.—Cutting of a muscle of the eye.

N

Nyctalopia.—Day-blindness or night vision.

Nystagmus.—Oscillation of the eyeballs.

O

Oculus bovinus.—Same as buphthalmos.

Oculus leporinus.—An eye like that of a hare.

Œdema.—Swelling of tissues due to effusion of serous fluid into same.

Onyx.—Deposition of pus in the cornea, causing it to become cloudy.

Ophthalmia.—Inflammation of the eye.

Ophthalmia neonatorum.—Purulent ocular inflammation in an infant.

Ophthalmitis.—Inflammation of the whole eyeball.

Ophthalmodynia.—Neuralgia or pain in the eyeball.

Ophthalmometry.—Measuring of the eyeball, its curves, etc.

Ophthalmoplegia.—Paralysis of the ocular muscles.

Ophthalmoptosis.—Protrusion of the eyeball, as result of paralysis of the muscles of the eyeball.

Ophthalmoscope.—Instrument for examining the interior of the eyeball.

Ophthalmotonometer.—Instrument used for measuring the intra-ocular tension of the eyeball.

Optogram.—A faint image stamped on the retina for a brief period.

Orthophoria.—Tending of the visual lines towards parallelism.

Oxyopia.—Preternatural acuteness of vision.

P

Pacheablephara.—Thickening of the eyelid.

Pannus.—A vascularization of the cornea.

Panophthalmitis.—Purulent inflammation of the whole eyeball.

Parallax.—Apparent displacement of an object.

Paralysis.—Loss of power of motion in a muscle.

Paresis.—Partial loss of motion in a muscle.

Perimeter.—An instrument for determining the extent of the visual fields.

Periorbita.—The periosteum of the orbit.

Periscopic.—Applied to lenses having a concavity on one side and a convexity on the opposite.

Peritomy.—Removal of a band of conjunctiva surrounding the cornea.

Phakomalacia.—Soft cataract.

Phimosis.—Abnormal smallness or narrowing, as of the palpebral fissure.

Phlyctenula.—A vesicle filled with a watery substance.

Photometer.—Instrument for measuring the intensity of light.

Photophobia.—Intolerance of light.

Photopsia.—Subjective appearance of light before the eyes.

Phthiriasis.—Pediculi among the lashes and hairs of the eyebrows.

Pinguicula.—A small tumour of the bulbar conjunctiva.

Pladarotes.—Thickening of the palpebral conjunctiva.

Presbyopia.—Far-sightedness—"old sight."

Pseudoisochromatic.—Similarity in colouration of objects seen by those with colour amblyopia.

Psorophthalmia.—Ophthalmia tarsi.

Pterygium.—Triangular vascular patch of thickened conjunctiva growing over the cornea.

Ptilosis.—Falling out of the eyelashes.

Ptosis.—Dropping of the upper eyelids.

Pyorrhœa.—Purulent discharge from the eye.

R

Retinitis.—Inflammation of the retina.

Rhexis.—Rupture of the eyeball.

Rhytidosis.—Collapsed or contracted state of the cornea.

S

Scintillans.—Sparkling before the eyes.

Sclerotitis.—Inflammation of the sclerotica.

Sclerotomy.—Incision into the sclerotic.

Scotoma.—Dark spot seen before the eyes.

Seborrhœa.—Increase of sebaceous flow.

Staphyloma.—A projection of some part of the globe, usually of the cornea and iris, or sclera and chorioid.

Staphyloma racemosum.—So called when it has a protuberant prolongation, and usually seen in more than one field of the cornea.

Stenochoria.—Obstruction of the lacrymal passages.

Stenopæic.—A disk with a narrow opening.

Stereoscope.—An instrument for exercising the muscles of the eye in functional anomalies.

Stillicidium.—Dropping of tears from the eyes in consequence of obstruction of the nasal duct.

Strabismus.—Squinting.

Symblepharon.—Adhesion of the lids to the eyeball.

Synchysis.—Dissolution of the vitreous body.

Synechia.—Morbid union of parts.

Synizesis.—Closure of the pupillary space.

T

Taraxis.—Slight external ophthalmia.

Tarsoraphia.—Suture of the tarsal margins.

Tarsus.—Cartilage of the eyelids.

Teichopsia.—Temporary amblyopia.

Tenotomy.—Cutting of a tendon.

Trachoma.—Granular conjunctivitis.

Trichiasis.—Abnormal eversion or inversion of the eyelashes.

Trichosis.—A small tumour on the front of the eyeball with hairs growing on it—like a mole.

Tylosis.—Induration of the borders of the lids.

U

Uvea.—Middle tunic of the eye.

Uveitis.—Inflammation of iris, ciliary body, vitreus and chorioid.

X

Xanthelasma.—Spots of yellowish discoloration on the eyelids.

Xanthoma.—Same as xanthelasma.

Xerosis.—Abnormal dryness of the eyeball exposed to the air.

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DISEASES OF THE EAR

By EDWARD BRADFORD DENCH, Ph.B., M.D.

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